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EDITORIAL

BUFFALOES IN PADDY CULTIVATION.

OVER the greater part of Ceylon buffaloes are preferred to bulls for paddy cultivation. In the undeveloped parts of the Island where paddy lands are close to large tracts of jungle and waste-land, the buffalo has the advantage of cheapness. The system of management is to turn the buffaloes loose in the adjoining jungle and waste-lands during the greater part of the year when they are not required for cultivation or threshing. Such a method of management certainly has the advantage of cheapness but it has the grave disadvantage that buffaloes handled in this fashion cannot be well-trained and docile. Indeed the great majority of buffaloes are so unruly and untrained that they cannot be used for ploughing, and as a result the commonest method of working the paddy fields is by " mudding "—that is driving a mob of buffaloes round and round the wet paddy land until it is churned into fluid mud. For the " mudding " of paddy lands it is essential that the land be first very thoroughly soaked with water. Rainfall alone is seldom sufficient to soak the land thoroughly and it is necessary to use water from irrigation tanks for the purpose. The result is that, in the first place, the start of cultivation has to be delayed until the tank fills and secondly that water which should have been available for the growing crops is wasted on the preliminary soaking of the land. The complaint is heard from the Irrigation Department that irrigation schemes designed to give water sufficient for a certain number of acres are in practice used to irrigate a considerably smaller area. These schemes were intended to supplement the rainfall, not to replace it. Because cultivation starts so late in the season the crop gets little benefit from the rains and demands are made on the tank supply at a much earlier stage of the crop than was anticipated when the schemes were designed. There is little doubt that dependence on " mudding " instead of ploughing is one of the main reasons for delaying the start of cultivation.

The solution lies in ploughing the land as soon as the land has been softened sufficiently by the rains. There are, of course, certain types of paddy lands which by their swampy nature or from the very heavy texture of the soil cannot be ploughed. Leaving these aside there are many paddy lands which could be ploughed if trained plough animals were available. The habit of unrestrained grazing has become so ingrained in the Ceylon buffaloes that it will be no easy matter to accustom them to the methods of management which will be necessary if they are to become well-trained, efficient plough animals. Indeed the opinion has been expressed that Ceylon buffaloes will not be suitable for such work and that a change over to bulls will be necessary if ploughing of paddy lands is to replace the present practice of " mudding ". The increasing development of the country and the consequent reduction of jungle grazing for buffaloes will make the problem more acute as time passes.

It is very probable that plough bulls which are more adaptable to confinement and stall-feeding will have to replace the buffaloes in many areas.

A STUDY OF THE CONTROL OF THE COCONUT CATERPILLAR (*NEPHANTIS SERINOPA* MEYR.) IN CEYLON WITH SPECIAL REFERENCE TO ITS EULOPHID PARASITE, *TRICHOSPILUS PUPIVORA* FERR.

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ASSISTANT IN ENTOMOLOGY

I.—INTRODUCTION

THE coconut caterpillar, *Nephantis serinopa* Meyr., is the only important caterpillar pest of the coconut palm in Ceylon. Periodical infestations of this pest occur in which much damage is done in the coconut areas situated along the east and sometimes the west coast. It feeds on the leaves eating away the underside of the older and lower palm fronds, and the leaflets, if badly infested, gradually curl up along their length and eventually die. In a bad infestation thousands of palms may be affected and only the upper three or four leaves may remain green and unattacked. It also attacks other palms and has been recorded on the palmyrah, the talipot, the wild date palm, the kitul palm, and certain other species of Palmaceae.

The adult insect is a small greyish moth (Plate I., figs. 1 and 6a) which usually rests with its two pairs of wings folded over the abdomen. The male moth is slightly smaller than the female. During the day time the moths are inactive and rest on the leaflets of the older leaves. (When disturbed they only flutter away for a short distance and soon settle down again.) They are active at night when mating and egg-laying usually take place. About two days after emergence from the cocoons, the moths start laying their eggs in batches, on the surface of the leaflets, usually on the under-surface or in rows in the grooves of the midribs. The eggs are laid daily for periods ranging from about 4 to 10 days, and as many as 350 eggs may be laid by a single moth. The eggs are oval in shape, very small, and of a creamy white colour when freshly laid. Before hatching they gradually turn pinkish (Plate I., figs. 2 and 2a). The eggs hatch in about 6 to 10 days. The young caterpillars (Plate I., fig. 3) have black heads and

pinkish bodies. Soon after hatching out they settle down in the groove of the midrib on the underside of a leaflet and soon form protective galleries with small pieces of leaf tissue and pellets of waste matter. These galleries are gradually extended to include fresh portions of the under surface of the leaflets and are widened as the caterpillars grow. If a large number of caterpillars start feeding on a single leaflet, this soon becomes covered with galleries and the attacked portions turn brownish-grey and die (Plate I., figs. 5 and 6). The caterpillar is full grown in 5 to 8 weeks during which it passes through five instars. The full-grown caterpillar spins its oval silken cocoon usually on the underside of the leaflet, covering it thickly with pieces of leaf and pellets of waste matter. The pupa (Plate I., fig. 4) is brown in colour and the instar occupies about 7 to 13 days. The average length of the whole life-cycle is about 61 days and 6 generations are completed in an year.

This coconut caterpillar was first observed in Ceylon in the Batticaloa District in 1900 by Green. A second outbreak was recorded in 1906 in the same district. Later, in 1907, the pest attracted serious attention in certain small areas on the western side of the Island specially in the Colombo District. In the year 1919, the coconut caterpillar came suddenly into prominence in the Batticaloa District and since then it has become the subject of periodical investigations. Soon after this outbreak in the Batticaloa District, the status of the pest was recognized and in September, 1921, it was declared a major pest under the Plant Pests and Diseases Ordinance. Since 1922 it has gradually spread to the more inland coconut areas and has been recorded in the Western and North-Western Provinces. Also about this period this caterpillar became a serious pest in certain areas in South India, and the Government of Madras brought in the aid of the Pest Act to enforce adequate artificial methods of control by large scale cutting and burning of infested fronds.

From 1921 onwards, various mechanical measures to control this pest have been tried. In recent years, however, the decrease in severity of this pest in certain coconut areas on the western side, where it had been periodically reported to be severe, has been partially attributable to the increased efficiency of its natural enemies and partly to other causes. During the year 1934, the eastern coast experienced an unusually long drought which gave rise to a severe outbreak of the pest in Batticaloa North and certain areas in the South. Since this outbreak, the pest has occasionally broken out in a few places in this area but has not succeeded in spreading very much, while in other parts of the Island it has become quite insignificant.

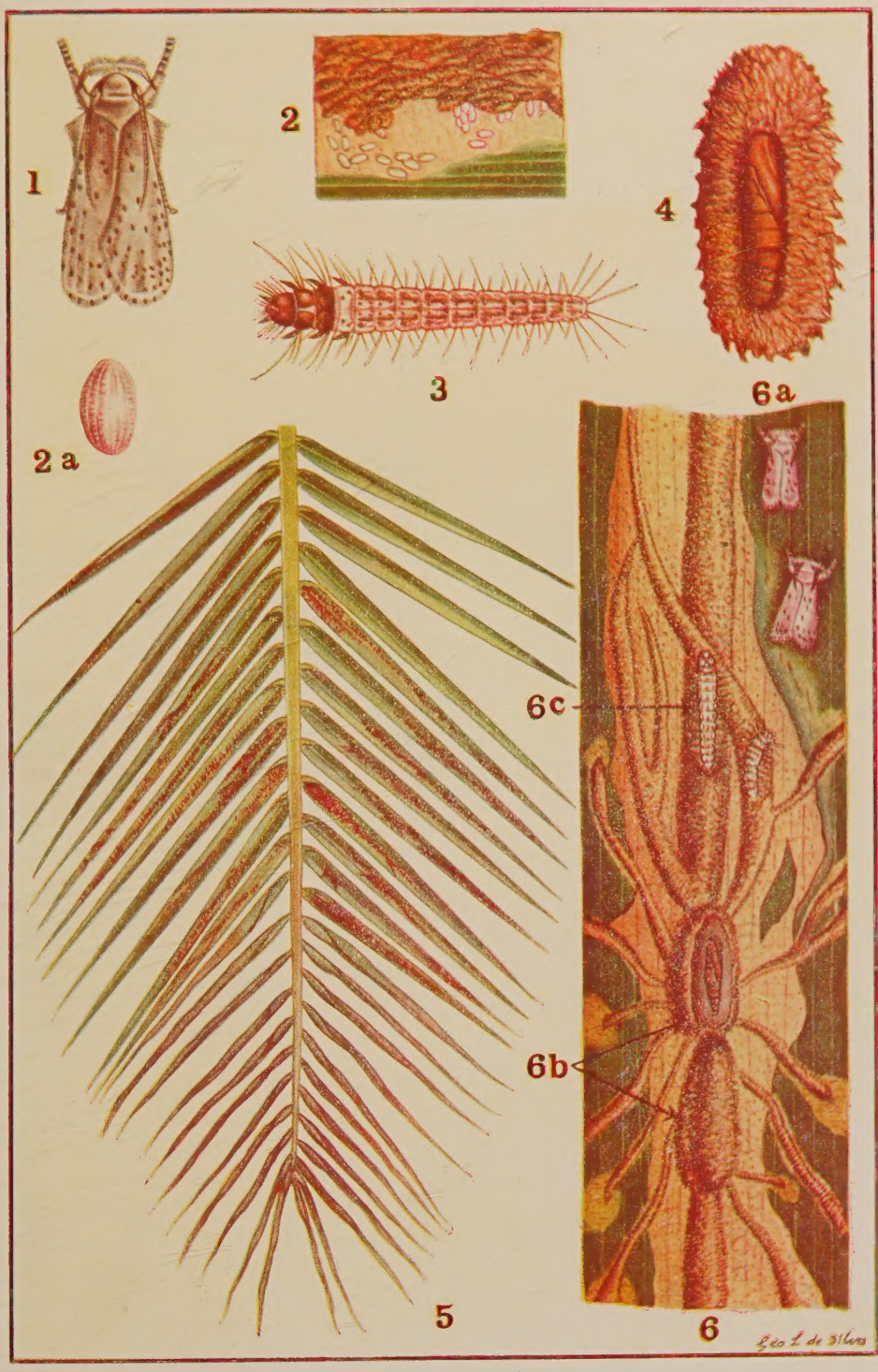
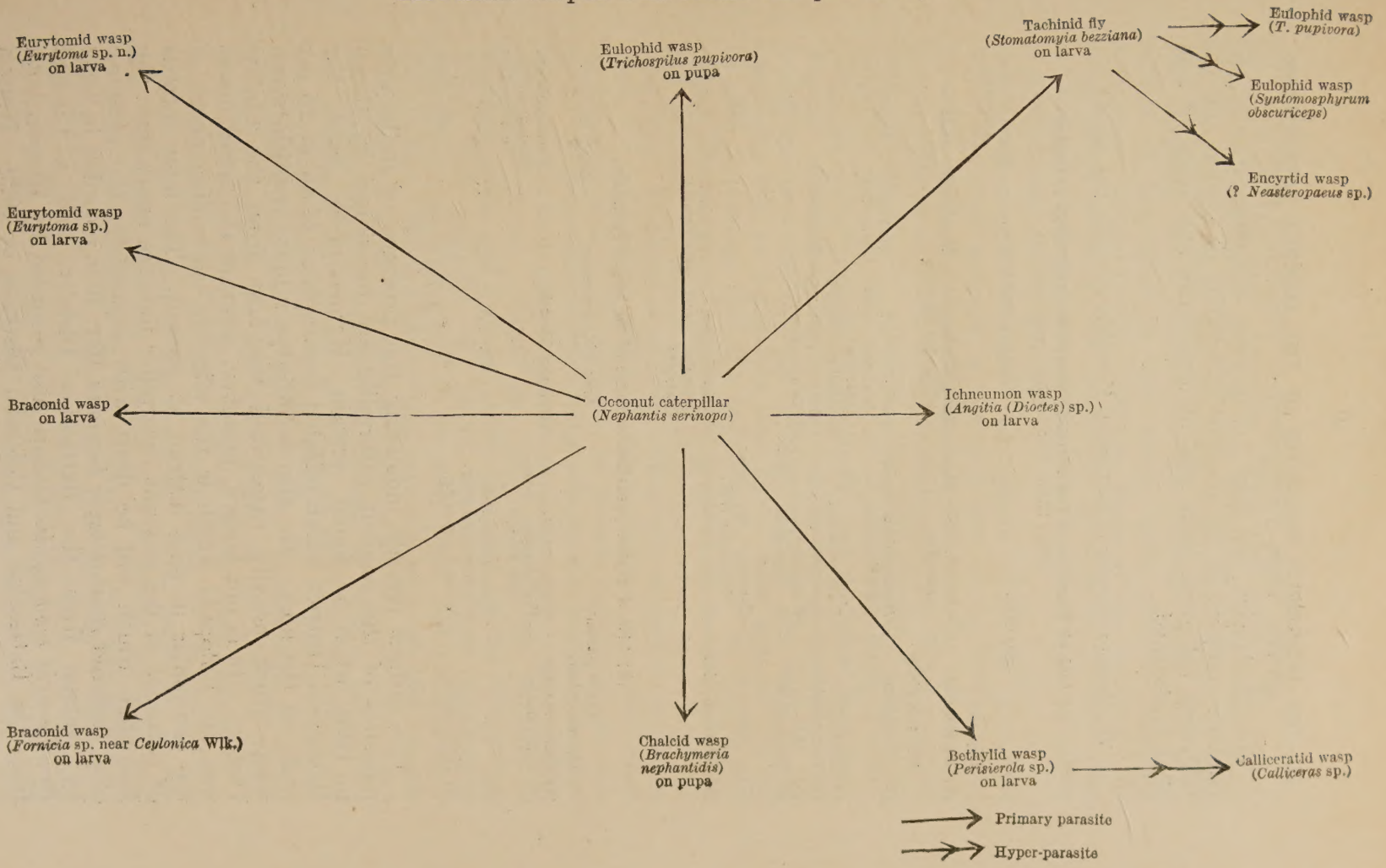


PLATE I.—THE COCONUT CATERPILLAR

(*Polgasthalambuwa*, S. *Thennolaipulu*, T.)

Figure 1.—Moth, resting position, × 3. Figure 2.—Eggs laid near edge of cocoon, those on left freshly laid, those on right near hatching, × 3. Figure 2*a*.—Egg, near hatching, × 15. Figure 3.—Full-grown caterpillar, × 3. Figure 4.—Cocoon turned over to show pupa, × 3. Figure 5.—Underside of attacked leaf showing galleries of caterpillars above and gray withered portion below, reduced in size. Figure 6.—Portion of attacked leaflet, natural size, showing damage and stages of the pest ; 6*a*, moths, male above, female below ; 6*b*, arrows showing (1) where eggs may be laid ; (2) galleries of young caterpillars starting from cocoons ; (3) two cocoons, one with top removed to show pupa inside ; 6*c*, caterpillars removed from galleries.

The Parasite Complex of the Coconut Caterpillar in Ceylon.


Eurytomid wasp (*Eurytoma* sp. n.) on larva
Eulophid wasp (*Trichospilus pupivora*) on pupa
Tachinid fly (*Stomatomyia bezziana*) on larva
Eulophid wasp (*T. pupivora*)
Eulophid wasp (*Syntomosphyrum obscuriceps*)
Encyrtid wasp (? *Neasteropaeus* sp.)
Eurytomid wasp (*Eurytoma* sp.) on larva
Braconid wasp on larva
Coconut caterpillar (*Nephantis serinopa*)
Ichneumon wasp (*Angitia* (*Dioctes*) sp.) on larva
Braconid wasp (*Fornicia* sp. near *Ceylonica* Wlk.) on larva
Chalcid wasp (*Brachymeria nephantidis*) on pupa
Bethylid wasp (*Perisierola* sp.) on larva
Calliceratid wasp (*Calliceras* sp.)
Primary parasite
Hyper-parasite

II.—THE INDIGENOUS PARASITES OF THE COCONUT CATERPILLAR (OTHER THAN *TRICHOSPILUS PUPIVORA* FERR.)

The illustration on page 5 expresses diagrammatically the parasite complex of the coconut caterpillar in Ceylon and the following list gives their area of occurrence and stage of host that is attacked.

The Parasite Complex of the Coconut Caterpillar in Ceylon (*See page 5.*)

(a) List of Parasites of the Coconut Caterpillar Indigenous to Ceylon (other than *Trichospilus pupivora*)

Parasite.		Area of Occurrence.	Stage of Host Attacked
Diptera			
(1) Tachinidae	—*Stomatomyia bezziana* Bar.	North-Western Province, Batticaloa District	Larva
Hymenoptera			
(2) Chalcididae	—*Brachymeria nephantidis* Gahan.	North-Western Province, Colombo and Batticaloa Districts	Pupa
(3) Bethylidae	—*Perisierola* sp. ..	Batticaloa District ..	Larva
(4) Eurytomidae	—*Eurytoma* sp. ..	Galle and Batticaloa Districts	do.
(5) Do.	—*Eurytoma* sp. n. ..	Batticaloa District ..	do.
(6) Braconidae	—A Braconid (undeter.)	do.	do.
(7) Do.	—*Fornicia* sp. near *Ceylonica* Wlk.	do.	do.
(8) Ichneumonidae	—*Angitia* (*Dioctes*) sp.	North-Western Province, Colombo and Batticaloa Districts	do.

(b) List of Hyper-parasites on some of the above Parasites.

Hyper-parasite		Area of Occurrence	Name of Host
Hymenoptera			
(1) Calliceratidae	—*Calliceras* sp. ..	Batticaloa District	.. *Perisierola* sp.
(2) Eulophidae	—*Trichospilus pupivora* Ferr.	do. ..	.. *Stomatomyia bezziana* Bar.
(3) Do.	—*Syntomosphyrum obscuriceps* Ferr.	do. ..	.. do.
(4) Encyrtidae	—*Neasteropaeus* Sp. ..	do. ..	.. do.

The earliest records indicating the presence of indigenous parasites of the coconut caterpillar are mentioned by Green in 1900, when he found certain Hymenoptera from the Batticaloa District which effected a parasitism of about 25 per cent. on the host. He also recorded a minute reddish-brown wasp which heavily parasitized the host from the Chilaw District. It is not known, however, whether the latter insect was the Eulophid which is the effective controlling agent of the caterpillar in that district at present. The later records of parasites of the coconut caterpillar indicate apart from the Eulophid, which will be dealt with separately, the presence of a Tachinid *Stomatomyia bezziana* Bar. first recorded in 1922 by Hutson from the Batticaloa District, and a Chalcid *Brachymeria nephantidis* Gahan. also recorded by Hutson both from the Batticaloa and Colombo Districts in 1929. Hutson

also recorded an *Eurytoma* sp. in 1929 in the Galle District. Apart from the three parasites mentioned above the writer during the course of the last five years has found five other parasites which have not yet been completely identified, and the foregoing list is based upon the material which has been reared or inspected by the writer from several hundred specimens obtained from different parts of the country. In most cases where a few specimens have been obtained the Imperial Bureau of Entomology, London, has so far not given a specific name to the insects.

(1) *Stomatomyia bezziana* Bar. (Plate III., fig. 4).—This Tachinid larval parasite is the only one of its family so far recorded on *Nephantis* in Ceylon. It has been for a long time a very efficient parasite along the east coast, but it has recently been found to be attacked by three hyper-parasites—an Encrytid and two Eulophids, one of the latter being *Trichospilus*, the pupal parasite of *Nephantis*, and the other *Syntomosphyrum obscuriceps* Ferr. The adult, which resembles the house fly, lays one or more whitish eggs on the back of the head of a half to full grown host larva. The eggs are placed in such a position that the host cannot reach or remove the eggs. The maggots that hatch out enter the host by piercing the skin and the empty egg capsules may often be seen on the host skin. In about a week the full grown maggot emerges out from the host larva, which in the meantime has been killed by the activities of the parasite, to pupate outside (Plate III, fig. 5). In those cases where a full grown larva is attacked the host larva is able to pupate before the parasite maggot can complete its larval period. When the host pupates the parasite is trapped inside and pupates inside the body of the host pupa. When this happens the adult parasite often encounters difficulty in emerging out of the host pupa and consequently dies inside. Though more than one egg may be laid on the host and all of them hatch out and enter the host not more than two maggots survive to emerge as adults, the others being starved out owing to want of sufficient nutrition for complete development. Even when two complete development the adults are very small in size. *Stomatomyia* is found in larger numbers in the drier parts of the coconut areas. It is the most conspicuous parasite in the early stages of a pest outbreak. In certain localized areas in the Batticaloa District this Tachinid is the dominant larval parasite. It has been observed that this parasite is now losing much ground in some areas owing to the activity of its hyper-parasites mentioned earlier. Among these hyper-parasites *Trichospilus* has been recorded only on two occasions and these were during periods when the host population of *Nephantis* was on the decline. It is possible that *Trichospilus* made *Stomatomyia*

an alternate host in the absence of the coconut caterpillar in the pupal stage. It is yet too early to say what effect *Trichospilus* will have on the activity of *Stomatomyia* in the future, but with large scale liberations of the former in infested areas and in the absence of suitable stage of the host it may seriously impair the latter's efficiency especially in areas where it has been observed to be dominant.

(2) *Brachymeria nephantidis* Gahan. (Plate II., fig. 6).—This Chalcid, a primary parasite of *Nephantis*, is at present the dominant and only indigenous pupal parasite on the eastern coast and it is a keen competitor of *Trichospilus*, the Eulophid pupal parasite that is being introduced into that area from the western coast. *Brachymeria* plays a minor part in the western coast where *Trichospilus* is dominant. In certain parts of the eastern coast it was observed on investigation in 1938–39 that an average parasitism of 20·1 per cent. was obtained by this Chalcid. The following table gives a record of the observations.

TABLE I.

Degree of Parasitism in the Field

Date of Examination	Total No. of Pupae obtained	No. of Pupae Parasitized by *Brachymeria*	Percentage of Parasitism
2. 8.1938	58	11	18·9*
3. 8.1938	67	18	26·9*
4. 8.1938	183	41	22·6
4. 8.1938	360	42	11·6
30. 8.1938	134	20	14·8
5. 9.1938	364	79	21·7
13. 9.1938	77	28	36·3
4.10.1938	520	69	13·2
6.10.1938	309	89	28·8
11.10.1938	273	50	18·2
29.10.1938	174	27	15·5
11.11.1938	168	39	23·2
29.11.1938	386	169	43·8
29.11.1938	214	38	17·7
9.12.1938	358	50	13·9
13. 1.1939	391	35	8·9
24. 1.1939	132	17	12·8
7. 2.1939	495	148	29·8
24. 2.1939	122	20	16·4
10. 3.1939	107	36	33·6
15. 5.1939	252	46	18·2
15. 5.1939	102	16	15·6
15. 5.1939	276	41	14·8*
15. 5.1939	287	21	7·3*

* *Trichospilus* was observed to be very active in these areas during these periods.

The adult wasp (Plate II., fig. 6) is of medium size, thick set, black in colour, with yellow bars on the legs. The female has a

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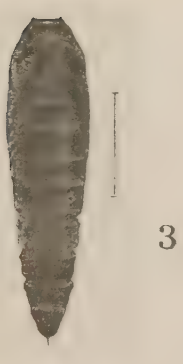

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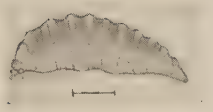

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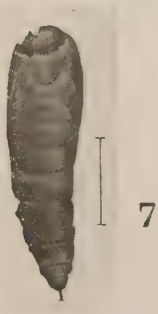

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PLATE II.

1. Pupa of *Trichospilus pupivora* × 20.
2. *Trichospilus pupivora* × 20.
3. Pupa of *Nephantis serinopa* parasitized by *T. pupivora* showing emergence holes × 3.
4. Grub of *Brachymeria nephantidis* × 4
5. Pupa of *B. Nephantidis* × 4.
6. *Brachymeria nephantidis* × 4.
7. Pupa of *Nephantis serinopa* parasitized by *B. nephantidis* showing emergence hole × 3.
8. *Perisierola* sp. × 5.
9. Cocoons of *Perisierola* sp. × 3.
10. A Braconid larval parasite × 5.
11. Cocoons of Braconid (10).

sharp ovipositor with which it pierces the skin of the host pupa and lays inside it one and very rarely two eggs. The grub (Plate II., fig. 4) that hatches out feeds on the contents of the pupa and when full grown pupates inside the host. At the end of the pupation period which lasts about 10 days the adult bites it way out through the anterior end or side of the host pupa (Plate II., fig. 7) leaving inside a thin pupal skin. The parasitized host pupa is almost black in colour and the parasite or the pupa (Plate II., fig. 5) may be clearly seen inside if the host pupa is held up against light.

(3) *Perisierola* sp. (Plate II., fig. 8).—This Bethylid wasp is another of the primary larval parasites that are of minor importance taking its place along with the two Eurytomids which are mentioned below. It is probably more efficient than the latter owing to its very active habit of dispersing rapidly and also locating its host. The adult is black in colour, slender and small in size with short legs. It appears to be a strong flier. It has been observed to attack the larvae of the host and sting them for the purpose of feeding on the body fluid, thus destroying a fairly good number of the host. The female lays about 15 to 20 eggs on the skin of a medium-sized host larva. The grubs that hatch out are ecto-parasitic in habit clinging to the host in a group and feeding by sucking its juices. When fully grown they leave the host to weave silken cocoons (Plate II., fig. 9) of a dirty-brown colour usually under or within the galleries made by the host larvae. The weakened host frequently tries to pupate but fails. This parasite has only been recorded in the Batticaloa District. It has also been found to be hyper-parasitized by a Calliceratid wasp, *Calliceras* sp. This was first recorded by the writer in 1937.

(4) *Eurytoma* sp. x. (Plate III., fig. 6) and (5) *Eurytoma* sp. n. (Plate III., fig. 8).—These two Eurytomid species are larval parasites of *Nephantis*. They are extremely scarce and apparently play a very insignificant part in reducing the host population. The first species was recorded in 1929 in the Galle District and the second species in 1925 in the Batticaloa District. The former is black in colour except for parts of its legs which are yellowish brown. The female has an exerted ovipositor. The eggs are apparently laid on the young larva and the parasite completes its growth before that of the host. When fully grown they emerge from the host and pupate in rather loosely woven silken light-brown cocoons (Plate III., fig. 7). It is not unusual to find the skin of the dead host larva sticking to these cocoons which are usually found in the groove of the midrib of leaflets. The latter species is very much smaller than the former. It is also black in colour. The antennae have a few whorls of hair. It has a diamond-shaped abdomen

with a distinct petiole. Its habits and life-history are similar to the former and the cocoons are usually found in the grooves of the midribs of leaflets.

(6) A Braconid wasp (undetermined). (Plate II., fig. 10).—This is recorded in several instances as a primary larval parasite of *Nephantis* in the Batticaloa District. When full grown it emerges from the host larva and pupates just outside the body of the host. The beautiful oval white cocoons (Plate II., fig. 11) are usually found sticking to the dead host larvae in the corners of the galleries of the latter and more frequently along the groove of the midrib of a leaflet. The adult emerges by cutting a circular lid at the top end of it. It is comparatively a minor parasite of *Nephantis*. The adult is black in colour with light brown patches on the tibiae and tarsi of the legs. It is thick set with fairly large wings and a medium sized ovipositor. It appears to be active in habit and a strong flier.

(7) *Fornicia* sp. near *Ceylonica* Wlk.—Little is known of this Braconid wasp beyond its being recorded as a parasite, presumably of the larval stage of *Nephantis*, but emergence takes place from the host pupa. This was recorded for the first and the only time by the writer in 1935, in the Batticaloa District.

(8) *Angitia* (*Dioctes*) sp. (Plate III., fig. 2).—This small Ichneumon wasp is one of the most dominant of the larval parasites of *Nephantis* in Ceylon. Its efficiency is becoming very marked in the east coast. It was first observed by the writer in 1935. It parasitizes early or middle stage host larvae only laying a single egg on each host larva. When the parasite grub (Plate III., fig. 1) is nearly full grown the parasitized host stops feeding and soon shrinks into an inanimate mass. A few hours later the naked full grown parasite emerges from the host's body and pupates after spinning its cocoon close to the dead host. The cocoon (Plate III., fig. 3) is sausage-shaped and pale in colour and darker at either end. At the end of the pupation period which lasts about 10 days the imago bites its way through the anterior end of the cocoon. The adults are very active and strong fliers and their slender form helps them to disperse rapidly. Parasitism was found to increase with the progressive age of the infestation of the host.

III.—PARASITES AND PREDATORS OF THE COCONUT CATERPILLAR RECORDED IN THE EAST AND WEST COASTS AND PLAINS OF SOUTH INDIA (OTHER THAN *TRICHOSPILUS PUPIVORA* FERR.)

The parasite complex of the coconut caterpillar is expressed in the illustration given on page 11 and the list that follows gives their area of prevalence so far recorded, stage of host that is attacked, and efficiency as can be judged from published accounts.

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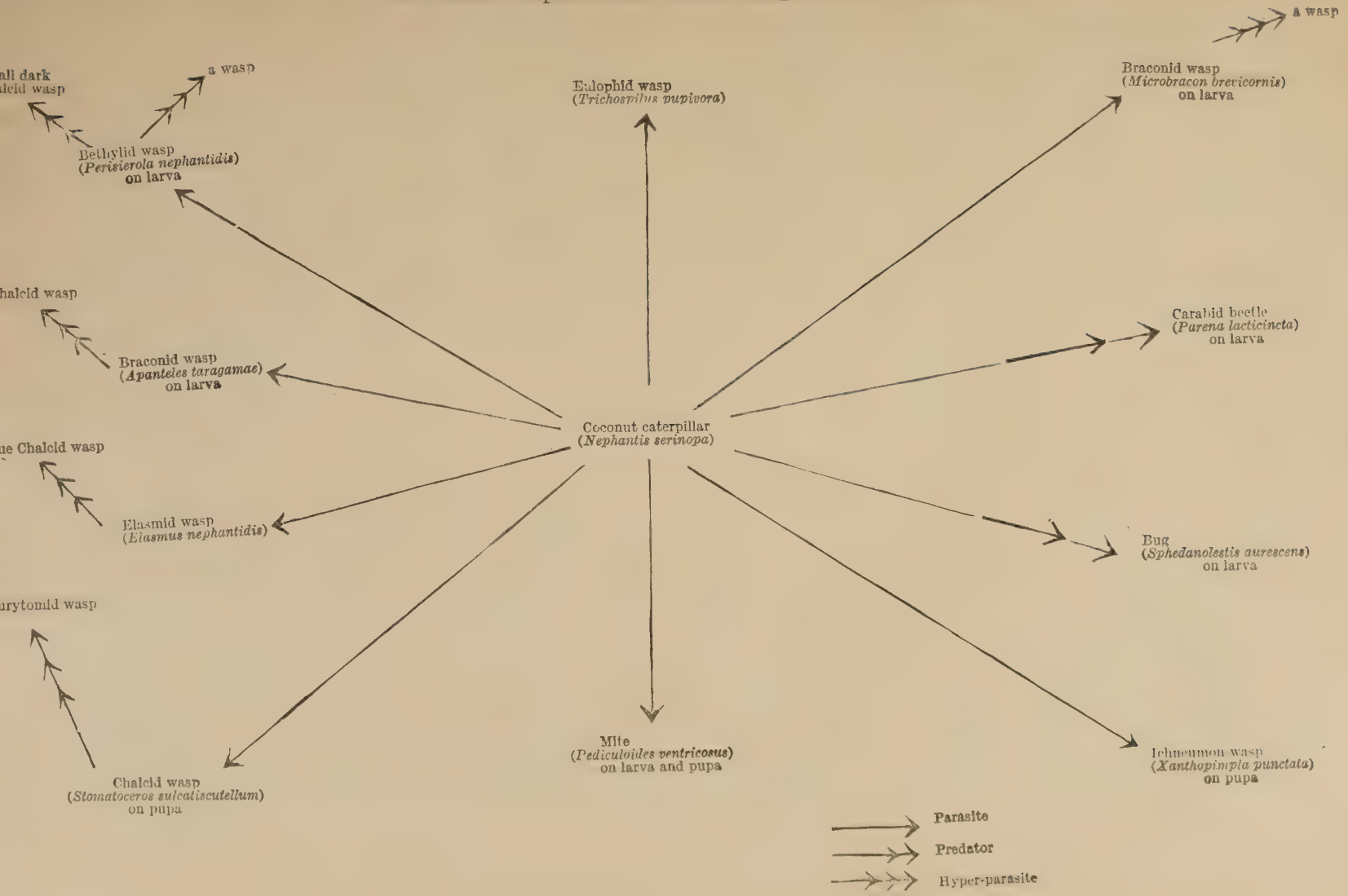
PLATE III.

1. Grub of *Angitia* (*Dioctes*) sp. × 4.
2. *Angitia* (*Dioctes*) sp. × 5.
3. Cocoon of *A.* (*Dioctes*) sp. × 2.
4. *Stomatomyia bezziana* × 4.
5. Puparium of *Stomatomyia bezziana* and parasitized *Nephantis* larva × 5.
6. *Eurytoma* sp. × 5.
7. Cocoons of *Eurytoma* sp. × 3.
8. *Eurytoma* sp. n. ? × 10.

The Parasite Complex of the Coconut Caterpillar in South India.



List of Parasites of the Coconut Caterpillar Indigenous to South India (other than *Trichospilus pupivora*)

Parasite	Area of Occurrence	Stage of Host Attacked	Remarks
Arachnida			
(1) *Pediculoides ventricosus*	—	Larva and Pupa	—
Hymenoptera, Bethylidae			
(2) *Perisierola nephantidis* M.	Coromandal Coast, Cochin	Larva	A fairly efficient parasite
Braconidae			
(3) *Apanteles taragamae* Vier.	Cochin, Plains of South India	do.	An efficient parasite
(4) *Microbracon brevicornis* S.	Cochin	do.	—
Elasmidae			
(5) *Elasmus nephantidis* R.	Cochin, North Arcot, Malabar, Travancore, Chingleput	do.	Degree of parasitism rather poor
Chalcididae			
(6) *Stomatoceros sulcatiscutellum* Girault.	Samalkota, Mangalore, Salem, Cochin, Coimbatore	Pupa	Parasitism rather poor
Ichneumonidae			
(7) *Xanthopimpla punctata* Ferr. Predator	—	do.	—
Coleoptera, Carabidae			
(8) *Parena lacticincta* (*Callida splendidula* F.)	Mangalore	Larva	Found in numbers. Efficiency rather poor
Hemiptera, Reduviidae			
(9) *Sphedanolestes aurescens* Dist.	—	do.	—

Of these parasites only the allied species of the Bethylid *Perisierola* has been recorded in Ceylon. There is also, of course, the Eulophid *Trichospilus pupivora* Ferr. which is indigenous both in India and Ceylon.

Though all the Hymenopterous parasites except the Ichneumon wasp *Xanthopimpla* are recorded to be hyperparasitized by several species of Chalcids and an Eurytomid, their efficiency in controlling the host caterpillar has not been observed to be impaired. This appears to be due to the effective multiparasitism exercised by them and absence of clash of competition. The Braconids *Apanteles* and *Microbracon* attack only young larvae, the Bethylid *Perisierola* attacks full-grown ones, while the Elasmid *Elasmus* attacks only larvae in their pre-pupal stage, and the Chalcid *Stomatoceros* attacks only the pupa. The team work among this circle of parasites on the different stages of the host appears to have a strangle-hold on the coconut caterpillar in certain parts of South India, especially in the Coromandel coast, in spite of its fecundity

IV.—THE EULOPHID PARASITE (*TRICHOSPILUS PUPIVORA* FERR.)

(Plate II., fig. 2)

Trichospilus pupivora belongs to the family Eulophidae of the order Hymenoptera. It is a small wasp and is one of the most important natural enemies which have been found to exert an appreciable influence on the population of the coconut caterpillar. It was first noted as a pupal parasite of the coconut caterpillar in the Negombo District in Ceylon in 1919 by Hutson, in Cochin on the Malabar coast in South India in October, 1925, in Sepang in the Malaya Peninsula and in Buitenzorg in Java; it has since been described by Ferriere and by Anantanarayanan.

(*a*) Habits and life-history of *Trichospilus*.—The adult insect is a minute parasitic wasp. Its head and thorax are orange-yellow in colour while the abdomen is brownish-black. It has large eyes and three ocelli, two lateral and one anterior. The wings are delicate, hyaline and somewhat smoky-brown in colour. There are two spots on each forewing formed by tufts of black hairs. The forewings are not shorter than the hind wings. The legs are quite yellow. The abdomen is almost rounded flat above with a short yellow quadrate petiole which is a little longer than broad. The male insect is smaller than the female. It has shorter antennae and legs, but the latter are thicker than those of the female. The abdomen of the female is more rounded and broader but much shorter than the thorax. The ovipositor is only visible from the ventral aspect. The females appear to be normally fertilized while within the host pupa as mating was rarely observed and then only immediately on emergence of the parasite from the host pupa. Parasites that emerged in the natural way were not observed to mate, but mating was always noticed when they were let out by artificially puncturing the host pupa. In such cases the parasites were given the opportunity to mate as otherwise they would not oviposit on the host pupae. It was noticed that one male fertilized a large number of females, accounting for the relatively small numbers of males. The adult insects lived up to 11 days in Peradeniya and 7 days in Batticaloa and 12 days in Kurunegala, the mean average temperature of these three places being 77·2°F, 81·3°F, and 80·7°F respectively. Their longevity did not appear to be increased by feeding on sugar solution or on honey and water. The females start ovipositing within two to six hours of emergence on any part of the host pupa and die from 3 to 6 days after oviposition. The largest number of eggs laid by a single female parasite was found to be 206, with an average of 133 for ten females. Under laboratory conditions the average number of eggs laid by a single female

parasite on a pupa of the coconut caterpillar was 248. From pupae collected in the field at Kurunegala and Batticaloa an average of 91 and 96 parasites emerged. The parasite was found to attack more than one host pupa and it parasitized even 8-days-old pupa of the coconut caterpillar, the average pupal period of the host being 12 days. Parasitized pupae when exposed to parasites with fresh unparasitized pupae were not attacked. The pupa of the host (Plate II., fig. 3) when parasitized is easily differentiated by the characteristic sickly dark colour which it develops on the sixth day.

The eggs of the parasite are not visible to the naked eye and they are very minute appearing as transparent streaks amongst the contents of the host pupa. In the laboratory at Peradeniya the eggs were observed to hatch in about 24 hours.

The larval period lasts for about 7 or 8 days and by this time the entire contents of the host pupa are devoured. The larvae, which have no appendages, when full grown turn into a naked pupae (Plate II., fig. 1) within the pupal case of the host. The whole pupal period is about 8 or 9 days, after which the fully-formed adults emerge by biting tiny holes through the pupal case (Plate II., fig. 3) of the host. The whole life-cycle from egg to emergence of adult is completed in 16 to 23 days according to weather conditions, being longer in wet weather and shorter when dry. The average life-cycle was found to take 20·4 days, and in one year 17 to 18 generations were completed in the laboratory at Peradeniya where breeding was carried on uninterruptedly for over a period of four years. At Kurunegala and Batticaloa 21 or 22 generations were completed in one year with an average life-cycle of 17 and 16·5 days respectively.

(*b*) Laboratory breeding of the parasite.—In the field the parasite has been recorded on *Tirathaba rufivena* Walk. in Malaya; pupae of *Tirathaba* spp. in Java; pupae of *Sylepta derogata* F. in Calicut in Malabar in South India; *Thosea cervina* Walk., *Spodoptera mauritia* Boisd., and puparia of a Tachinid parasite of *Nacoleia annubilata* Swinh. in Ceylon; and pupae of *Nephantis serinopa* Meyr. in South India and Ceylon. Of the three records from Ceylon more evidence is necessary to accept the first two, namely, on *Thosea cervina* and *Spodoptera mauritia*. In the laboratory the parasite did not oviposit when several species of insects belonging to the family Limacodidae were exposed to it, the pupal case being too hard for it to pierce. And further on several occasions pupae of *Thosea cervina* were exposed to it and the parasite failed to oviposit on them. Though in the laboratory the parasite readily parasitized pupae of *Spodoptera mauritia*, the writer has not so far observed it on this Noctuid collected in the field where *Trichospilus* was naturally prevalent.

Besides it is hardly possible for this parasite to oviposit in the body of the pupa of *Spodoptera* because the latter pupates in the soil in an earthen cell quite beyond the reach of the parasite. Further, attempts made by the writer in the laboratory to make the parasite attack pupae which had pupated in earthen cells in the soil were not successful.

In the laboratory at Coimbatore, in South India, the parasite was successfully bred on the pupae of the following :—*Acontia graellsi* Feist., *Cnaphalocrocis medinalis* Gn., a Pyralid on grape vine, *Ergolis merione* Cr., and a Hesperiid coconut caterpillar. In the laboratory at Peradeniya, it was successfully bred on the pupae of the following :—(1) *Spodoptera mauritia* Boisd., (2) *Sylepta derogata* F., (3) *Prodenia litura* F., (4) *Tiracola plagiata* Wlk., (5) *Cosmophila erosa* Hubn., (6) *Plusia* spp., (7) *Terias silhetana* Wallace, (8) *Parnara bada* Mo., (9) *P. mathias* F., (10) *Borolia venalba* Mo., (11) *Homona coffearia* Nietner, (12) *Catopsilia crocal* Cram., (13) *Psara bipunctalis* F., (14) *Polytella gloriasae* F., (15) *Margaronia caesalis* Wlk., (16) *Stomatomyia bezziana* Bar., (17) Tachinid puparia—larval parasite of *Sylepta derogata*, and (18) Tachinid puparia—larval parasite of *Spodoptera mauritia*.

The parasite can be easily bred in the laboratory in large numbers under the climatic conditions at Peradeniya provided that suitable host material is made available. Pupae of *Spodoptera mauritia* which can be easily bred in the laboratory on grass, and pupae of *Prodenia litura* and *Tiracola plagiata*, both of which can be reared on castor and dadap leaves, were successfully employed as host material for breeding the parasites. From a single pupa of *Tiracola*, *Spodoptera* and *Prodenia* a maximum number of 1211, 904, and 823 parasites respectively were obtained. The parasites were successfully bred even on 10-days-old *Tiracola* pupa and 6-days-old pupae of *Prodenia* and *Spodoptera*, the pupal period of the former being about 16 to 18 days and of the two latter about 12 days. The host larvae are frequently afflicted by a bacterial disease when a large number of them are destroyed very suddenly, so that great care has to be taken to keep the breeding cages clean and dry and any overcrowding of larvae in a cage avoided. The host insects are not always available in the field in appreciable numbers. With a little care and forethought, however, it is possible to maintain a constant supply of host material. With the aid of a refrigerator it has been found possible to keep pupae and even egg masses in cold storage. This method helps to maintain a stock of larvae of all stages which will yield pupae almost daily. Glass specimen tubes, $4\frac{1}{2}$ in. by $1\frac{1}{2}$ in., with cotton plugs are suitable for breeding. In each tube 4 host pupae may be supplied to

20 parasites, if the host pupae belong to any of the above-mentioned species. In the case of pupae of smaller size the parasites per pupa should be reduced to two. More than one parasite was found to ovipost in a single pupa. Diseased or unhealthy pupae are not attacked. When a variety of species of host pupae were supplied to them in the same tube no partiality was shown to pupae of any particular species, not even to the natural host, the coconut caterpillar pupa. The breeding tubes must be clean. During moist wet weather parasitized pupae in the tubes become subject to fungoid attack which destroys them and eventually the parasites within them. Fresh healthy pupae should be supplied to the parasites. All diseased and unhealthy pupae, extraneous matter or parasites which have died after ovipositing in the tubes must be removed and the tubes kept clean and dry. The parasites can be easily introduced from tube to tube as they are photo-trophic and move towards light. It was possible to breed uptodate uninterruptedly 84 generations of the parasite, and to send out for liberation on an average about 1,500,000 individuals per month. The parasites were sent in tubes by post to destinations which were reached in about two days, and they were observed to stand the journey very well.

V.—ATTEMPTS AT BIOLOGICAL CONTROL OF THE COCONUT CATERPILLAR BY INTRODUCTION OF *TRICHOSPILUS PUPIVORA* FERR.

As stated earlier *Trichospilus pupivora* is indigenous only to the west coast of Ceylon and in India to certain areas in the south including, roughly, Travancore, Cochin, and Mangalore. In these places it is the most effective parasite of the coconut caterpillar, and hence attempts have been made from time to time to utilize it for biological control in other areas where the coconut caterpillar pest occurs but in which the parasites did not appear to occur naturally.

(*a*) *Attempts made in South India.*

In South India the first attempt to utilize this parasite was made in 1924 when it was imported from the west coast together with the Bethylid and the Braconid parasites and introduced into Mangalore where it is reported to have failed to establish itself. In 1925 another attempt was made to re-introduce it into the same area and was met with some success. The introduction in both cases was effected by obtaining large consignments of infested leaflets with parasitized material from areas from the west and east coasts, the only enemies of the pest at the time in the district being the Chalcid wasp—*Stomatoceros sulcatiscuttelum*, a pupal parasite—and a predatory Carabid beetle—*Parena lacticincta*, attacking the larva. It

appears that from time to time the Eulophid was also artificially bred and introduced into Mangalore. No record of the subsequent history of the pest in Mangalore has been published and it is not known to what extent the introduced parasite established itself. It may be mentioned that the climate of Mangalore is very much like that experienced on the west coast of Ceylon.

Another attempt that was made in South India was the introduction of the parasite into the dry areas of Coimbatore in 1925, where it appears to have failed to establish itself. The climate of Coimbatore is similar to that of the east coast of Ceylon.

(*b*) *Attempts made in Ceylon.*

In Ceylon attempts have been made to introduce the parasite into the east coast where it has not been known to occur naturally. The east coast coconut estates are not continuous with those in the west and central parts, being separated by a rather wide belt in which there are no coconut plantations. It has also much drier climatic conditions than those experienced by coconut estates in the west and central parts of the Island, and it is, perhaps, on account of these conditions that this parasite has not been able to establish itself here as yet. The first attempt to introduce the Eulophid was made in 1922 when small consignments were sent to two estates in Batticaloa North and South respectively. They were, however, received in a dying condition and it is possible that no actual healthy parasites were eventually liberated into the area.

A second attempt was made in 1926 when another consignment was sent to an estate in Batticaloa South. Here again insufficient care was taken in the liberation of the parasite and it is possible that the attempt was unsuccessful. In any case it was not subsequently possible to obtain evidence of them in the field in either of these attempts. In 1927, however, a more thorough attempt was made when several consignments of parasites were sent to many estates in the South and North of Batticaloa. Later inspections, however, did not reveal any signs of the parasites and it appears that this attempt was also unsuccessful. In 1935, following a very severe outbreak of the pest an organized attempt was made to breed the Eulophid in large numbers for liberation in the Batticaloa District. In November of that year several consignments of parasites were obtained from the western coast of South India, through the kind courtesy of the Government Entomologist, Agricultural Department, Madras, and laboratory breeding was carried out on a large scale at Batticaloa and on a small scale at Peradeniya. The breeding station at Batticaloa was later abandoned in 1935 as it was found that difficulties

had to be encountered in rearing the host material necessary for the parasites, and also the parasites bred seemed to be rather weak and numbers obtained relatively small. Since October of that year the breeding of the parasites was exclusively confined to Peradeniya where it was very satisfactorily carried out. The large number of parasites bred were sent by post in tubes to the Field Officers of the Agricultural Department and to Estate Managers for liberation in infested areas. From time to time observations were carried out both in the field in the Batticaloa District and in the Laboratory at Peradeniya by examination of infested leaflets. Table II. indicates the results of these investigations carried out for a period of ten months during the years 1938 and 1939 when the pest was prevalent in certain areas.

TABLE II.

Results of Investigations in 1938 and 1939

Date of Examination	Name of Estate	Date of previous liberation of parasites	Total No. of pupae obtained	No. of pupae parasitized by *Trichospilus*	% of parasitism by *Trichospilus*	% of diseased or otherwise parasitized Pupae	Remarks
2. 8.38	Tirrukovil	29. 7.38	58	25	43·2	56·8	A leaf cut from each of five trees selected at random and infested leaflets selected and examined for pupae which were dissected or kept under observation for parasites.
3. 8.38	Thambiluvil	18.12.37	67	34	50·7	47·7	
4. 8.38	do.	18.12.37	183	8	4·3	34·9	
4. 8.38	Easter Seaton	1. 7.38	360	—	—	26·1	
30. 8.38	New Tirrukovil	11. 8.38	134	1	·7	32·8	
5. 9.38	Thambiluvil	4. 8.38	364	25	6·8	38·1	
13. 9.38	*Pilacholai	17. 8.38	77	—	—	48·0	
4.10.38	New Tirrukovil	15. 9.38	520	—	—	17·3	
6.10.38	Thambiluvil	8. 9.38	309	14	4·5	42·3	
11.10.38	*Pilacholai	4.10.38	273	5	1·8	23·4	
29.10.38	New Tirrukovil	14.10.38	174	3	1·7	27·0	
11.11.38	*Pilacholai	1.11.38	168	3	1·8	32·1	
29.11.38	New Tirrukovil	7.11.38	386	4	1·0	57·7	
29.11.38	Thambiluvil	13.10.38	214	16	7·9	29·4	
9.12.38	*Pilacholai	22.11.38	358	5	1·3	19·5	
13. 1.39	Loxton/Palmlands	9.12.38	391	70	17·1	12·5	
24. 1.39	*Pilacholai	22.11.38	132	12	9·0	17·4	
7. 2.39	Easter Seaton	7. 1.39	495	61	12·3	38·7	
24. 2.39	*Pilacholai	6. 2.38	122	6	4·9	19·6	
10. 3.39	Easter Seaton	7. 1.39	107	8	7·4	48·5	
15. 5.39	Loxton/Palmlands	9. 1.39	665	248	37·2	13·8	
15. 5.39	Easter Seaton	7. 1.38	252	21	8·3	22·2	

* Estates in Batticaloa North. The others were in Batticaloa South.

VI.—DISCUSSION

In the biological control of an insect pest a large number of factors must be taken into consideration. To begin with the area to be covered by parasite colonization must be circumscribed and more or less continuous and should possess within its limits more or less equable climatic conditions. Secondly the presence of other parasites which would lead to a condition of multiparasitism should also be considered, as the absence or elimination of the less effective ones might be favourable. At the same time several parasites might have the advantage of a superior balancing effect in that they are not all likely to suffer from deleterious factors. Thirdly, there is the presence of hyper-parasites, namely, insects which are parasitic on the primary parasites of the pest to be considered, since this has an obvious importance on the control effected by a primary parasite. On the other hand, this factor may not be so

important as it seems since secondary parasites seem to be incapable of hindering extensively the primaries which they attack, mainly because the percentage of primary parasites which they succeed in finding increase directly as the concentration of the primaries; and the percentage cannot approach an appreciable figure until the primaries are already sufficiently plentiful to suppress the pest.

The most important factor, however, is the particular nature of the parasitic insect itself. *Trichospilus pupivora* may be considered on the whole a very effective and successful parasitic insect. It has relatively a very short life-cycle with an average length of about 16·5 days, as compared with the life-cycle of its host which occupies about 60 days. A single female *Trichospilus* is capable of laying up to 200 eggs and can parasitize more than one host pupa. It can also parasitize host pupae which are as old as 8 days and each parasitized pupae can yield anything up to 200 adult parasites. Another factor which further heightens its rapid rate of increase is that the females outnumber the males. This is made possible by the ability of a single male to fertilize several females. Also it has but little tendency to superparasitism, the female being capable of discerning already sufficiently parasitized pupae. Otherwise this factor can seriously affect its value, as an environment which is capable of yielding a certain number of parasites progressively will in consequence of superparasitism be so exploited that it would produce fewer parasites. In addition to the features mentioned *Trichospilus* has also got rather active habits and a highly developed power of dispersal which is equal to if not greater than that of its host. Though its optimum conditions are relatively cool and damp weather with a temperature of about 80°F and a relative humidity of 92–94, it can also tolerate higher temperatures up to about 85°F and relative humidities as low as 78, although its rate of reproduction and vitality may be reduced in such conditions by half or more.

In the western parts of Ceylon and South India where it is normally in what may be regarded as its natural habitat, the evidence shows that it is the controlling factor of the population level of the coconut caterpillar. In these parts this pest generally possesses a population level which makes its activity quite negligible to the planter. Under such conditions the parasite is only limited in its activity by the scarcity of the host. Nevertheless the environmental conditions are so favourable to the parasite that it is capable of rapid and extensive dispersal so that it is able to maintain itself even under these conditions of low population level. It also appears in this region to be totally free from hyperparasites and enjoys

very little competition from other parasites. This is no doubt due to its better dispersal value, its greater power of locating host material, and its relatively high rate of increase in which it greatly surpasses the other parasites, and is thus able to quickly dominate a situation in which all these parasites are present.

In considering its chances of survival in the new or introduced environments into which it has been artificially brought these factors assume much greater importance. To begin with it has to tide over a period of weather conditions which are definitely unfavourable for it. This is the long dry hot spell which extends in the east coast from May to September. During this period of 3 to 4 months it passes through 6 to 10 generations during which time its vitality and activity would become greatly reduced. Under such conditions it is likely to hold on successfully only if there is a relative abundance of host material. Under these circumstances, the other parasites of the host will also be a serious competing factor. Of these the most important are the larval parasites especially *Angitia* and *Stomatomyia*. The activity of the latter is, however, checked by three hyperparasites. Records taken during times of relative host scarcity tend to show that the local parasites do exert a very strong controlling influence on the pest. It is only when the host has become very numerous that the local parasites are apparently unable to cope with the greatly increased numbers, their rate of multiplication being relatively slow and cycle of development relatively long. It is in these circumstances that *Trichospilus* would be useful, and if it is capable of tiding over the spells during which the weather conditions are unfavourable and the host relatively scarce, there is no doubt that it would be effective in keeping the pest under control in the eastern part of the Island. It is with this possibility in view that attempts have been made to introduce the parasite into this region. Further, it is also possible that though it may be unsuccessful in establishing itself in the first few attempts, repeated attempts carried out over a fairly long period might be successful in giving it a chance of readjusting its physiological requirements to such an extent as to be capable of getting established. Further, even if it is eventually shown that it is incapable of doing this, artificial liberation of the parasite might still be an effective and practical control measure to be applied in serious outbreaks of the pest in this region.

In conclusion it can be stated that as far as can be seen at present the chances of *Trichospilus* establishing itself in the eastern district seem to be poor, although it is not possible to rule it out altogether as a possible control factor until the

observations are carried out for several more years. That the continuous liberations of large numbers of the parasite which have been done during serious outbreaks in various parts are of definite value in checking these seems more or less evident, though even this needs to be confirmed by more extensive experiments and observations.

VII.—SUMMARY

1. The history, bionomics, and distribution of the host caterpillar are briefly described.

2. The parasite complex of the host is described with brief accounts of the life-history and habits of the parasites as far as observed by the writer within the past five years.

3. A detailed description of the habits, life-history and laboratory breeding of the Eulophid parasite is given.

4. The attempts at control by introduction of this parasite are described and discussed.

5. Finally the possibilities of utilizing this parasite as a biological control factor in the east coast of Ceylon are discussed.

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SOME DISEASES OF GARDEN PLANTS

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GERBERA LEAF BLOTCH

GERBERA JAMESONI Bolus, more familiarly known as the Barberton daisy, is grown extensively in Ceylon gardens for its flowers. During wet weather the leaves often have a blotched appearance due to death of parts of the leaf blades, and if the wet period is prolonged, the disease may become so severe that entire leaves die.

The first sign of the disease is usually to be found on expanded leaves as small reddish-brown spots on the upper surface, or as similar discolorations of the leaf tip. These areas become larger and darker in colour and ultimately turn black (Pl. I., fig. 1). The dead areas are usually bounded by the mid rib and larger veins on three sides but extend to the leaf margin on the fourth as, usually, there is no large vein in that region to prevent extension. Some of the dead areas may fall out of the leaves later, usually during dry weather (Pl. I., fig. 2). When the disease has been severe and large areas of leaves have been destroyed, the leaves may become irregular in shape, and appear as though parts had been eaten away by caterpillars (Pl. I., fig. 3). In very severe cases, the majority of the leaves of each plant may be entirely destroyed, but the plants recover during fine weather as the leaf buds are rarely attacked. Flowers and flower stalks are not affected.

When sections are cut through diseased areas, stained and cleared in hot lactophenol with cotton blue, eelworms may be observed within the leaf tissue. If the diseased tissue is teased apart with needles in a small quantity of water in a watch glass and allowed to stand for a short time, about half an hour, the eelworms may be seen, with the aid of a hand lens, swimming about in the water. They are small and transparent, but in shape and motion they resemble minute eels from which their common name is derived.

FIG. 1. FIG. 2. FIG. 3.

PLATE I. *Gerbera Jamesoni* leaves attacked by *Aphelenchoides olesistus*

Fig. 1—Early stage of attack showing leaf blotch.
Fig. 2—Showing dead tissue fallen from the leaf.
Fig. 3—Severe attack.

Eelworms, or nematodes, are known to attack the leaves of numerous plants and to cause symptoms similar to those described above in gerbera. At various times different scientific names have been applied to these worms, *e.g.*, *Aphelenchoides fragariae* was used to denote the species found on strawberry, *A. ritzema-bosi* the one on chrysanthemums and *A. olesistus* on ferns and other plants. Other names have also been used to denote the worms attacking leaves of other plants. Experts are now of the opinion that many of these names must be abandoned as they are being applied to mere host varieties or biological races of at most one or two species. Steiner, and American authority, regards them all as varieties of one species, *viz.*, *A. fragariae*. Goodey, an English authority, claims to be able to separate two species by certain morphological characters and maintains the name *A. olesistus* for the second species.

The eelworms found in Gerbera leaves exhibit the characters by which Goodey distinguishes *A. olesistus*. That name is therefore used in this paper.

The writer has been unable to locate any previous record of *A. olesistus* attacking *Gerbera Jamesoni*. In Ceylon, however, it is a common pest of gerberas.

LEAF BLOTCH OF THE OX-EYE DAISY

Somewhat similar blotches are found on the leaves of the Ox-eye daisy (*Chrysanthemum leucanthemum*), which is a common plant in up-country gardens, the flowers being used for decoration purposes. The blotches are brown, with a yellowish fringe or border and contain numerous eelworms of the species *A. olesistus*. Injury to this plant is not so severe, as a rule, as to gerbera. Flowers are not attacked.

A. olesistus has been recorded elsewhere as a pest of *C. leucanthemum* (2).

PURPLE BLOTCH OF BACHELOR'S BUTTON

A few Bachelor's Button plants (*Gomphrena globosa*) growing in one garden were observed to have purplish blotches on the upper and lower surfaces of the leaves. These plants had reached the flowering stage and every leaf showed such purplish patches, which were most extensive on the basal leaves of each plant. The leaves did not wither.

On teasing the purplish blotches in water a very large number of *A. olesistus* worms were collected. They could be seen under the microscope wriggling from within the torn leaf tissues. From one piece of leaf about half a square inch in area, over a hundred worms were counted. From stained sections of the purplish blotches it was definitely established

that the worms were living endoparasitically in the leaf tissues. No dead cells were seen in the sections but the purple discoloration extended through the infected tissue.

No previous record of an attack by *A. olesistus* on *Gomphrena globosa* has been located.

PENSTEMON LEAF DROOP

Penstemon barbatus is another common plant of up-country gardens. In this plant, although the eelworm causing damage is the same species (*A. olesistus*) as found on *Gerbera Jamesoni*, *Gomphrena globosa*, &c., the symptoms produced are very different. These plants grow to a height of $1\frac{1}{2}$–2 feet and normally carry all their leaves till the flowering period is over.

The first leaves to be attacked are at the base of the plant, and infection is first apparent as minute purplish spots on the upper surface. These spots are similar to those produced on *Gomphrena globosa* leaves but are not so deeply coloured. The spots, if weather conditions are favourable, spread rapidly and eventually form rusty-coloured areas which cover the whole leaf. Later these leaves wither and hang down alongside the stem (Pl. II., fig. 1). The most characteristic symptom of the disease in this plant is the withering and droop of the oldest leaves from the base upwards for a considerable height above the ground. A badly infected plant at the flowering stage shows the dead leaves hanging down alongside the stem. Above these is a zone in which the lower leaves are rusty-coloured and in various stages of withering ; the upper leaves stand out in their normal position, but have purplish spots an blotches. Above this zone the leaves may be normal and healthy. The flowers are not infected.

A. olesistus worms were collected in large numbers by teasing the purplish patches of leaf in water. On sectioning the leaves eelworms and eggs in all stages of development were seen. The purplish discoloration of the leaf is confined mostly to the epidermal cells. No worms were found in the dry dead leaves.

A LEAF BLOTCH OF SALVIA

A leaf blotch of *Salvia farinacea* similar to but not so extensive as of *Gerbera Jamesoni* was found during the wet weather. The blotches which were brown or black were confined mostly to the edges of the leaf and between the larger veins. Heavy infection during wet weather in a few cases caused wither and droop of the older leaves as in *Penstemon barbatus*.

On teasing the diseased tissue and in sections, *A. olesistus* was found. *A. olesistus* has been recorded as a pest of *Salvia splendens* and Salvia sp. elsewhere (2) but, so far as is known, this is the first record of the disease on *Salvia farinacea*.

FIG. 1.

FIG 2.

PLATE II.

Fig. 1—*Penstemon barbatus* showing symptoms of attack by *A. olesistus*. Note the dead leaves hanging alongside the stem.

Fig. 2—Chrysanthemum plant attacked by the fungus *Septoria obesa*. The lower leaves are dead and hang down while the upper leaves are blotched.

CHRYSANTHEMUM LEAF DISEASE

Chrysanthemum plants have been observed showing symptoms very similar to those produced on *Penstemon barbatus* in that the lower leaves were dead and hanging down alongside the stem (Pl. II., fig. 2). No purple spots, however, were seen on the upper leaves, but brown spots ranging in size from mere dots to large blotches were present. The flowers and flower buds withered prematurely.

This droop of the leaves and the presence of leaf blotches in temperate climates, is usually symptomatic of an eelworm attack by the species *Aphelenchoides ritzema-bosi*, which is possibly identical with *A. olesistus*.

Sections of the diseased blotches and the teasing apart of the infected leaves in water failed to reveal this or any other species of eelworm. Another species of eelworm was, however, collected from washings of diseased leaves, and in very large quantities from washings of diseased flower buds from one garden. These worms were kindly identified by Dr. T. Goodey of the Imperial Institute of Agricultural Parasitology as *Panagrolaimus rigidus* (Schneider 1866) Thorne (1937). Dr. Goodey in his letter regarding this eelworm writes, " The nematodes are examples of *P. rigidus*. It is a very common nematode here occurring naturally on grass and in all sorts of situations. I have never found it in diseased chrysanthemums but I know the U. S. A. nematologists regard this or the very closely related *P. subelongatus* as capable of setting up diseased symptoms. So far, I believe, no one has been able to set up disease in plants grown in inoculated soil ".

Although a search has been made for this or other species of eelworms in diseased chrysanthemum plants with the characteristic leaf droop symptoms, none has been found except in the above mentioned instance. Any suggestion that *P. rigidus* is the cause of this disease cannot, therefore, be maintained and the presence of that eelworm on those particular specimens must be regarded as accidental. The worm was probably living there as a saprophyte.

A fungus, however, was found common to every chrysanthemum plant showing those typical symptoms, when the leaf blotch in its early stages and sepals of withering flowers were examined. This fungus was identified as *Septoria obesa* which has been previously recorded from Japan (3). The pycnidia, 86–173μ in diameter were produced on both surfaces of the leaf and could be found both in the blotched areas and in healthy tissue near the junction of diseased and healthy areas. Spores were thick and rounded near the base, tapering towards the apex, up to 9 septate, measuring 66–87$\mu \times 3 \cdot 2$–$3 \cdot 6\mu$.

CONTROL

No attempt has been made to determine the life history of *A. olesistus* in Ceylon and the following suggestions are based on the observations recorded by other workers elsewhere.

A olesistus is able to move over the surface of plants in a film of moisture, so its migration is limited to wet weather. It is evident that the worms can travel against the downward flow of surface water, otherwise their presence on the upper leaves of *Penstemon barbatus* would be difficult to explain. Entry is made into the leaf tissues via the stomata and it is probable that some movement within the tissue also occurs. Large veins seem to form impassable barriers to worms within the tissue, though they are easily passed by worms moving on the surface of the leaf.

Eggs are laid within the leaf tissue and the life cycle from egg to egg probably occupies about 14 days. Unfortunately both eelworm and eggs can withstand desiccation. The eelworm commonly found in chrysanthemum leaves in temperate climates is known to have remained viable within desiccated chrysanthemum leaves for as long as three years and to have revived when the leaves were remoistened.

The ability of the worms to withstand desiccation is of great importance when methods of control are considered. Garden coolies often remove diseased Gerbera leaves and lay them on the surface of the bed as mulch or bury them in the soil as green manure. Such treatment can only result in heavier infections later. The disposal of diseased leaves in compost heaps or pits involves the risk of dispersal of the pest to other parts of the garden when the compost is used. To keep the eelworm population in check it is imperative that all diseased leaves should be burnt.

Known infected soil should be avoided when planting susceptible plants. Planting material should, if possible, be free of the pest. This is most easily achieved when the plants are raised from seed. When propagating from cuttings, these should be taken, if possible, from parasite free stocks. Before splitting the root stocks of gerberas the soil should be washed away from the roots with water containing not more than one per cent. of ammonia and then planted in parasite-free soil.

Warm water treatment is often useful in the treatment of this type of eelworm. The aerial parts of rooted cuttings are immersed in water at 50°C. (122°F) for 5 minutes, care being taken to keep the roots from drying. Root stocks, before the cuttings are taken, should be immersed for 5 to 10 minutes in water at 50°C. after the soil has been washed from the roots.

Goodey (1) reviewing the work done with the allied species *A. fragariae* states that most investigators have found the parasite most difficult to reach by chemical treatment. Sulphur and copper compounds, potassium permanganate, barium chloride, picric acid, sodium carbonate, lime water, mercury, arsenic and nicotine preparations in soft soap solutions at concentrations which do not injure plants were found to be useless.

Control of the chrysanthemum disease mentioned here calls for different measures as the parasite concerned is a fungus. Spraying with a fungicide, such as Bordeaux mixture, at frequent intervals and the removal of infected leaves would act as a check on further spread of the disease.

SUMMARY

(1) Diseases of *Gerbera Jamesoni*, *Chrysanthemum leucanthemum*, *Gomphrena globosa*, *Penstemon barbatus* and *Salvia farinacea* due to attacks by the leaf eelworm *Aphelenchoides olesistus* are recorded. Characteristic symptoms on these plants are described.

(2) A disease of Chrysanthemum plants due to attack by the fungus *Septoria obesa* is described. The symptoms were somewhat similar to those recorded in temperate climates as a result of attack by the eelworm *Aphelenchoides ritzema-bosi*. The eelworm *Panagrolaimus rigidus* was observed in one case, as a saprophyte, on the diseased leaves and flower buds.

(3) Control measures are discussed.

ACKNOWLEDGEMENT

I wish to record my thanks to Dr. C H Gadd, Mycologist of the Tea Research Institute of Ceylon, for his encouragement and advice during these investigations and his helpful criticism in the preparation of this paper.

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PERIODICITY OF NITRIFICATION

PART II. RUBBER AREA

ALEXANDER BRUCE, B.Sc., F.I.C.

IN rubber areas besides the natural nitrogen content of the soil there are annual additions to the supply of nitrogen by the leaf fall from the rubber trees, which is small, and leaf droppings from cover crops of the green manure variety. Rubber, being a deciduous tree, drops its leaves annually during February and March. It is well known that deciduous plants absorb practically the whole of the plant food from the leaves before shedding them so that it is not much more than the carcase or woody framework of the rubber leaf that reaches the soil. On the other hand the green cover crop cuttings have the organic matter fully represented in sugar, starch, &c. Pruned trees and bushes, as on the tea areas, have the leafy material full of organic matter which stimulates bacterial action, when incorporated into the soil. Under the same conditions microbiological activity will be less in a rubber area than in a tea area.

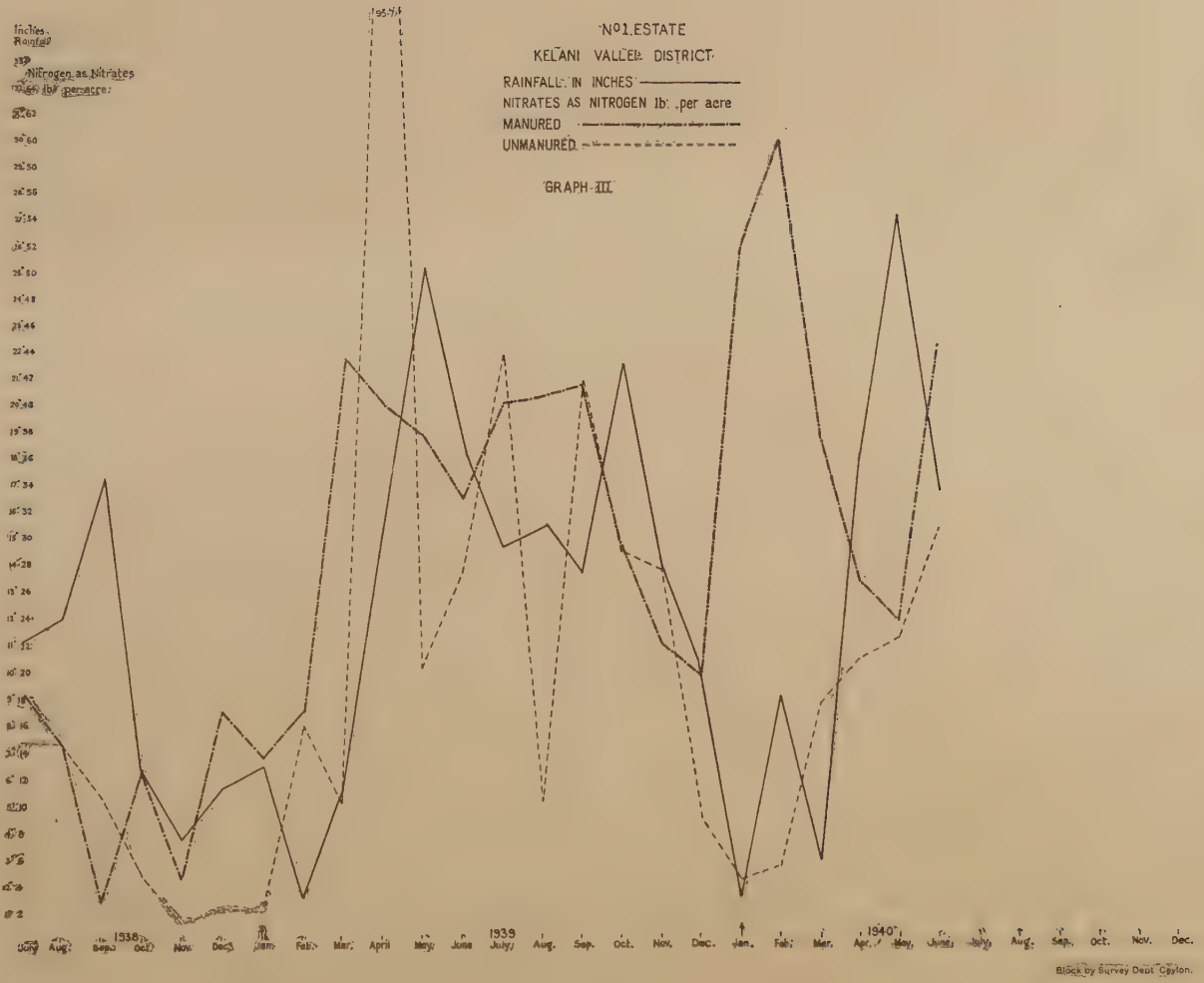
Rubber trees grow under semi-forest conditions. There is little mechanical cultivation in a rubber area. Drainage and terracing are practised. In the forests of Europe there are no nitrates found and it is stated that the trees absorb the nitrogen from the soil in the form of ammonia, not nitrates. It may be that, when nitrates are poor in rubber soils, resort has to be taken to both nitrates and ammonia for nitrogen food.

KELANI VALLEY DISTRICT

No. 1.—Estate.

General Data.—This estate was opened in rubber from jungle ; the oldest area opened in 1906–1907, is unmanured at present. The manured area was opened in 1911–1916.

The half millimetre sieve (60 mesh) passes 57 per cent. of soil in the manured area and 50 per cent. in the unmanured area. There is about 30 per cent. gravel present. The nitrogen in the dry soil is about 3,260 lb. per acre in the manured area and 2,865 lb. per acre in the unmanured area. The reaction p.H. is about 6. Carbon : nitrogen in the manured area is 14·4 and in the unmanured area 13·6. No nitrites were found during the period of experiment.


No1. ESTATE
KELANI VALLEY DISTRICT
RAINFALL IN INCHES
NITRATES AS NITROGEN lb. per acre
MANURED
UNMANURED
GRAPH-III
Inches Rainfall
Nitrogen as Nitrates lbs. per acre.
1938
1939
1940
July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. April May June July Aug. Sep. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sep. Oct. Nov. Dec.

Block by Survey Dept. Ceylon.

No. 1.—KELANI VALLEY DISTRICT

Table III

Month	Rainfall			Nitrates as Nitrogen, lb. per Acre.	
	Inches	Intensities		Manured	Unmanured
1938		Days.	Per Cent.		
July	11·08	5	81	18·3	14·7
August	11·96	7	63	14·6	14·5
September	17·20	5	48	3·8	10·5
October	6·24	3	59	12·3	4·6
November	3·68	1	33	4·4	1·2
December	5·60	2	45	16·8	2·10
1939					
January	6·43	3	70	13·4	2·0
February	1·38	1	74	16·8	15·7
March	5·63	3	61	43·4	9·8
April	15·34	5	65	39·8	95·7
May	25·09	5	88	37·3	20·2
June	17·98	7	59	32·7	27·3
July	14·36	5	52	38·9	43·6
August	15·22	—	—	40·4	10·1
September	13·33	—	—	41·3	41·7
October	21·24	—	—	29·1	28·8
November	13·46	—	—	21·8	27·3
December	10·15	—	—	19·1	8·6
1940					
January	1·45	—	—	51·9	4·1
February	8·89	—	—	59·9	5·2
March	2·76	—	—	37·6	17·4
April	17·95	—	—	26·4	20·7
May	27·17	—	—	23·5	22·3
June	16·72	—	—	44·3	30·4
Nitrogen as Ammonia				14	16·7

Rainfall and Nitrates Table III., Graph III.—Nothing could be deduced from the crops submitted for inspection, as they have been too much interfered with by man. The period starts in July, 1938, and is continued until June, 1940.

Intensities of rainfall have been recorded for a year from July, 1938, to July, 1939, from daily rainfalls. The following year 1938–1939 intensities were not recorded as they are not of so much importance as in the tea areas, except for tapping data.

Nitrogen as ammonia amounted to 14 lb. per acre on the manured area and 16·7 on the unmanured area.

On the unmanured area nitrates are poor from October, 1938, until January, 1939, and again from December, 1939, until February, 1940. These low nitrate periods are important as they are the months when high nitrates are required to stimulate the leaf renewal after wintering and before wintering to stimulate

the shedding of the leaf and produce a clean leaf callus. Rainfall is normal and does not give an explanation for the low nitrate. It may be that the high rubber crops of these periods, and before, have been the cause of the nitrate absorption from the soil solution.

Referring to table and graph III. nitrates are not present in quantity until the month of March on the manured area and April 1939 on the unmanured area. The rainfall of July and August, 1938, of 11 in. and 12 in. did not have a greatly diminishing effect on the nitrates but in the September 1938 rains of 17 in. nitrates dropped particularly in the manured area. They rose again in October, to fall again in November and rose again in December. Rainfall in the meantime was low at 6 in. or less. On the unmanured area nitrates fell steadily from July and continued low until January. Rainfall was poor in February, 1939, and then rose steadily until it reached a high peak of 25 in. in May. Nitrates started to rise in February on both areas. March saw a great increase in nitrates in the manured area which fell in the unmanured area then rose to the highest level of all the results in the month of April. After the high rainfall of May, 1939, rains remained steadily high until September and then rose in October to 21 in. The rainfall did not effect the nitrates much on the manured area, but kept up well until September; then the high rains of October reduced nitrates until December. On the unmanured area, nitrates decreased with the high rains of May, 1939, but rose again to a peak in July, fell again in August, then rose to a peak in September and then gradually fell away until December, January, and February, 1940, with low results and then with gradual increases until June. On the manured area, on the other hand, nitrates increased to a high level in January and February, 1940, the highest reached in this area, and then fell away until April and May with the high rainfall, followed by a nitrate rise in June.

High rainfalls of September 1938, May 1939, October 1939, May 1940, did not always highly depress the nitrates. The September 1938 rains decreased nitrates in the manured area but in the unmanured area there was no sudden depression. The May 1939 rains did not greatly depress the nitrates in either area. October rains did not give a sudden depression of nitrates but a gradual depression extending over 2–3 months. The May 1940 rains depressed nitrates but with the continued high rains in June nitrates increased. There is not the same rhythmic rise and fall in nitrates and rainfall as has been shown in the Tea area.

The incidence of manuring should be noted in above. January 1940, March-May, 1939.

Artificial Manuring was carried out in January 1940 with a cyanamide, phosphate, potash mixture containing 40 lb. of

nitrogen per acre. The results can be seen in the increase of nitrates during that period. During 1939 a ground-nut, cyanamide, phosphate, potash mixture was applied containing 30 lb. of Nitrogen per acre applied from March to May. The higher nitrates are noted extending for several months. During March–May 1938, ammonium sulphate, phosphate mixture was applied containing 51 lb. of Nitrogen. This was outside the experimental period.

Owing to the poor nitrification results laboratory trials were made with the addition of lime water and again in the field with burnt lime on an experimental scale. It was found that the addition of 1 cwt. burnt lime per acre was sufficient greatly to increase the nitrates within a month ; 3 to 6 cwt. of burnt lime per acre were also tried but there was no benefit from the increase in burnt lime.

KELANI VALLEY DISTRICT

No. 2.—Estate.

This estate was opened in rubber from jungle in 1906–1916. The manured area is the younger portion and was opened in 1911–1916. The unmanured area was opened in 1906–1917, rainfall 180 in.

On the manured area, fine soil passing the 60 mesh sieve (0·5 mm) is 63 per cent. The nitrogen amounts to 3,585 lb. per acre. Carbon : nitrogen is 13·6. Reaction p.H. is about 6.

On the unmanured area fine soil amounts to 69 per cent. Nitrogen per acre amounts to 3,117 lb. per acre. Carbon : nitrogen is 15·1. No nitrites were found during the period of examination.

KELANI VALLEY DISTRICT

Table IV

No. 2.—Estate

Month	Rainfall			Nitrates as Nitrogen lb. per Acre	
	Inches	Days	Intensities	Manured	Unmanured
1938			Per Cent.		
August ..	13·83	4	51	15·5	14·0
September	22·16	9	74	12·7	10·4
October..	8·25	4	64	2·4	2·3
November	6·45	3	50	103	17·2
December	7·77	2	43	82·1	78·9
1939					
January	5·91	3	59	31·6	32·9
February	0·85	—	—	40·2	48·6
March ..	5·07	2	47	11·1	9·2
April ..	17·56	6	66	22	17·0

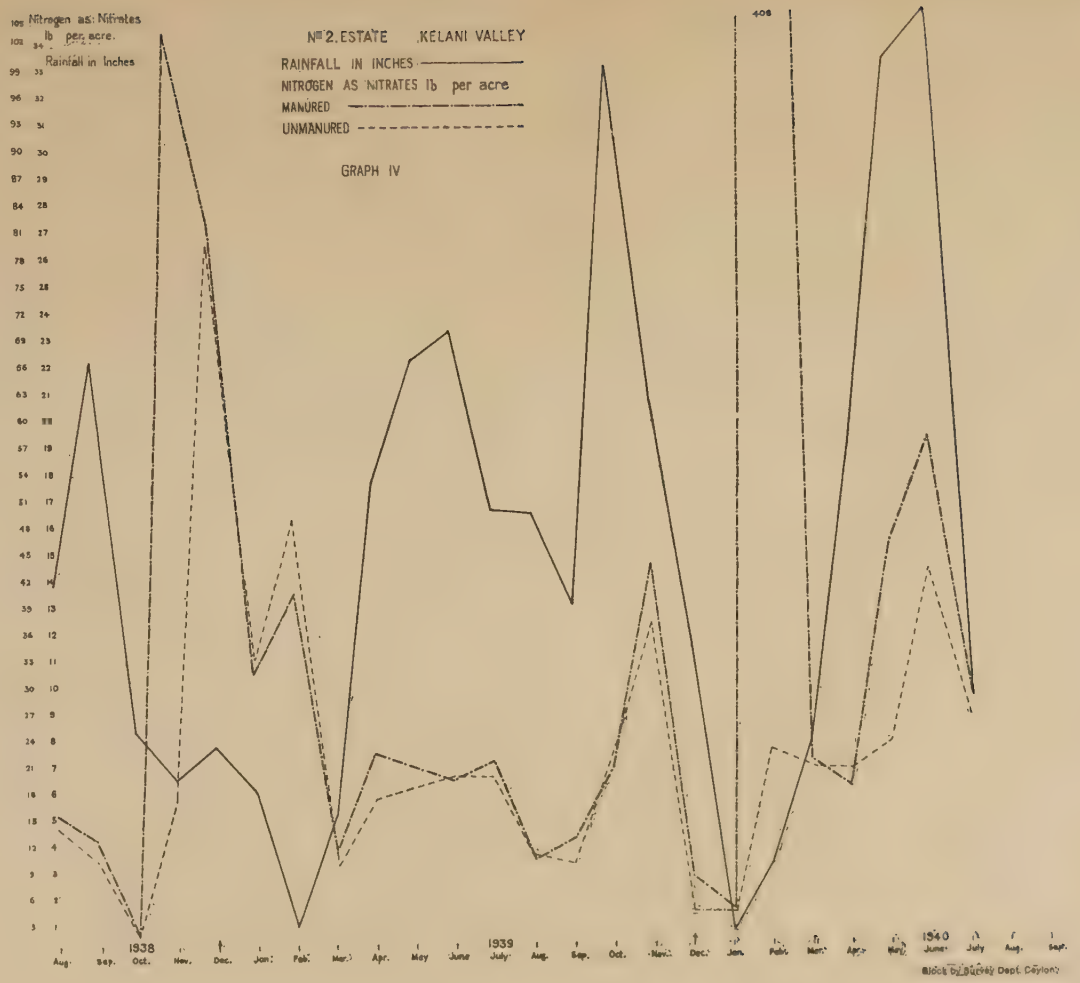
Table IV.—*contd.*

Month	Rainfall			Nitrates as Nitrogen lb. per Acre	
	Inches	Days	Intensities	Manured	Unmanured
1939			Per Cent.		
May	22·04	4	84	—	—
June	23·18	11	76	19·2	19·0
July	16·45	7	56	21·1	19·4
August	16·29	—	—	10·3	10·3
September ..	12·93	—	—	12·3	9·6
October.. ...	33·16	—	—	20·5	21·9
November ..	20·48	—	—	43·6	36·6
December ..	11·27	—	—	8·0	4·2
1940					
January ..	0·60	—	—	4·5	4·0
February ..	3·14	—	—	408	22·5
March	7·72	—	—	21·4	20·3
April	18·98	—	—	18·1	20·4
May	33·23	—	—	45·4	23·6
June	35·18	—	—	57·3	42·2
July	10·26	—	—	27·8	26·6

Rain intensities have been noted for the first year, but as they are not of so much importance as the tea area they were discontinued.

During the high rains of August and September 1938, April-November 1939, April-June 1940, nitrates were not depressed as on the tea area with high rains. The low nitrate of December and January 1940, in both areas, are not due to rainfall but as explained under No. 1 estate may be due to the draw of the trees on soil nitrates for the heavy crop in the last quarter of the year. The low nitrates of October 1938, may be due to the rains of August and September but as high rains have not greatly depressed nitrates at other periods, the explanation given above is repeated.

Graph IV. (see page opposite) has peak rains in September 1938, with a gradual fall for 5 months until March 1939. Rains then rise and there are high rains for 8 months until November 1939. There is a down peak in nitrates in October 1938, in both areas corresponding to the high rainfall of September. Nitrates maintain a high level during November-February, then fall in March 1940. In spite of the 8 months rain April-November 1939, nitrates kept up a fair standard. The high rains of October-November correspond to the low nitrate level in December and January 1940. The nitrates had risen from August to a peak in November. Rains reached a low level in January 1940, then gradually rose to a high peak in April-June then a fall in July. Nitrate manured graph followed the unmanured graph. Increase of nitrate during high rains is noted in November 1939 and June 1940.


Nitrogen as: Nitrates lb per acre.
Rainfall in Inches
No 2. ESTATE .KELANI VALLEY
RAINFALL IN INCHES
NITROGEN AS NITRATES lb per acre
MANURED
UNMANURED
GRAPH IV
1938
1939
1940
Aug. Sep. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sep. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sep.
Block by Survey Dept. Ceylon.

Nitrates amount to 0·7 per cent. of the total nitrogen in the soil. Besides the nitrates, nitrogen as ammonia was found to the extent of 22·5 and 26·3 lb. per acre in the manured area and 13 and 17 lb. per acre in the unmanured area during June and July 1940. If these figures are taken into consideration the broken down protein matter of the soil amounts to 1·2 per cent. of the total nitrogen in the soil.

Liming experiments were tried in the laboratory and in the field on an experimental scale at the rate of 1, 3, and 6 cwt. burnt lime per acre. There was no great increase in nitrates due to the addition of lime.

Artificial Manuring.—

In 1928, 4 cwt. ammonium sulphate per acre were applied containing 89 lb. nitrogen ;

1935 2½ cwt. ammonium sulphate plus phosphate per acre were applied containing 50 lb. nitrogen ;

1938 400 lb. ammonium sulphate plus phosphate per acre were applied containing 80 lb. nitrogen ;

1940 300 lb. Nitrate of soda plus phosphate and potash were applied containing 45 lb. nitrogen ;

application made in February-March.

The remarkable nitrate result of 408 lb. nitrogen per acre on the manured area can be explained as due to the manure application being made during February low rainfall on a dry soil due to the previous dry month of January, The result was that the nitrate of soda did not get properly disseminated in the soil.

Shade ground temperature of the rubber area is about 85–87° F and 2–3° lower in the top inch of soil. The sun ground temperature is about 110°F.

Physiology of the Rubber Tree.—The function of all living matter is to reproduce its species, Failure in that function is failure in life's history. During the interval between the flowering period and the shedding of the seed crop, trees are building up reserves for the trying and exhaustive period of their main function. After the seed crop has been shed about August the trees again build up reserves for the future seed crop to complete the annual cycle. More latex is prepared and stored by the trees, which is taken advantage of by man to produce raw rubber. The big production of raw rubber during the year is after the seed crop has been shed, that is during the last quarter of the year. Latex extraction is an exhausting and unnatural process and the trees have to draw on the soil for more nutrients than is normally the case during the year. If the soil is deficient in the essential soil nutrients the trees are unable to carry out the full vegetative process demanded of it. When the seed crop is being shed trees have been known to have a secondary leaf-fall and occasionally the seed case remains

attached to the mother tree owing to the connecting tissue not having been severed by the covering callus ; the result is the seed case gets sodden with water and all the conditions for fungus growth are present which when established frequently infects the bark.

To avoid these adverse conditions it is advisable to have the trees in a condition to carry out their vegetative function by having the necessary nutrients in the soil.

To keep up soil nutrient supply it is advisable to manure in August or late July and again in December-February according to weather conditions in order to ensure a continual supply of necessary soil nutrients This system is considered better than waiting until the soil nutrients fall to a low level as noted in the closing months of the year and the early months of the new year, and then making one application of fertilizer to satisfy the trees' requirements for a year.

Messrs. A. Baur & Co., Ltd., arranged with the agents of the estates to have soil samples taken and forwarded to the laboratory. To Messrs. A. Baur & Co., Ltd., Messrs. Whittall & Co., Messrs. Harrisons and Crosfield and their Superintendents of the estates thanks are given for all the trouble they have taken in supplying details and soil samples.

The tests were made by Messrs. A. J. Cameron and P. J. Edward to whom due acknowledgement is made.

THE SPECIES OF ECHINOCHLOA IN CEYLON AND THEIR OCCURRENCE AND DISTRIBUTION AS WEEDS OF PADDY LAND

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THE grasses represented by certain species of *Echinochloa* are capable of growing under semi-aquatic conditions and some occur in Ceylon as noxious weeds of paddy land. They rapidly multiply causing heavy infestations which result in a serious loss in the yields of paddy.

There has been some confusion as regards the particular species of *Echinochloa* which are found as weeds in paddy fields and little information is available on the distribution and relative seriousness of the infestations caused by each species in different parts of Ceylon. Paddy cultivators do not fully realize how fast these weeds can spread in their fields and how necessary it is that prompt measures should be taken for their eradication. These weeds not only interfere with the growth of the paddy plants but also attract the paddy fly (*Leptocorisa varicornis* F.), because they flower much sooner than even the earliest maturing variety of paddy. They have been found in flower when the paddy crop is only a month old and, thereafter, a succession of plants may appear in flower, past the harvest of the paddy until the fields are ploughed and cleared of all weed growth for the next season's crop. These weeds, therefore, provide an alternate host for the paddy fly almost throughout the year.

This article has been prepared with the object of describing the species of *Echinochloa* which are found in Ceylon, all of which the writers consider to be serious weeds of paddy fields.

An examination of specimens of *Echinochloa* from various parts of Ceylon has shown that there are four species which occur in the Island, viz.: *E. colona*, *E. frumentacea*, *E. crus-galli* and *E. stagnina*.

These weeds are known by such local names as *maruk*, *wel marukku*, *goma-tana*, and *gojarawalu* in Sinhalese and *kolichudan* and *kuthiraivali* in Tamil.

2. Botanical characters.

The genus *Echinochloa* Beauv. is distinguished from other closely related genera by the following characters :—

(1) The inflorescence is a panicle of spike-like racemes which arise on one side of the axis and not all round it.
(2) The spikelets are not silky.
(3) The glumes are entire (not notched) and are awned or cuspidate.
(4) The lower glume is abaxial.
(5) The leaves are linear.

The plants are annual or perennial and tufted in habit. The inflorescence is a panicle of spike-like racemes which arise on one side of the axis. The spikelets are ovate or lanceolate and are awned or cuspidate. The lower glume is smaller than the others and 3 to 5—veined. The upper glume and sterile lemma are sub-equal and 5 to 7—veined. The fruiting lemma and its palea are coriaceous or crustaceous and polished. The grains are elliptical.

The genus consists of about 25 species, distributed in the warmer parts of the world. Four species are recorded in Ceylon.

3. Key to the Species occurring in Ceylon.

Ligule absent ; annual

Awn absent :

Racemes distant ; spikelets in 3 to 5 rows, sessile ; stems slender, erect or decumbent, 1 to 2 ft. high .. .. 1 *E. colona*

Racemes crowded ; spikelets irregularly crowded, mostly in irregularly pedicelled fascicles of 3, of which one at least is sessile ; stems stout, erect, 2–4 ft. high .. .. 2. *E. frumentacea*

Awn $\frac{1}{4}$ to $\frac{3}{4}$ in long .. 3. *E. crus-galli*

Ligule a fringe of stiff hairs; perennial; awn 1/10 to $\frac{1}{4}$ in. long .. .. 4. *E. stagnina*

4. Notes on the Species.

(*a*) *Echinochloa colona* (L.) Link (Plate I., fig. 1.)

A slender, annual grass growing up to 2 ft. in height, tufted in habit with erect or decumbent stems which on touching the ground root at the nodes. The plants are green or purplish and often exhibit wide purple transverse bands across the leaf blades.

The *stems* are terete and glabrous, except on the nodes which are sometimes obscurely pubescent.

PLATE I.

Fig. 1—*Echinochloa colona.*

1. Inflorescence.
2. Portion of stem and leaf showing the ligule.
3. Front view of spikelet showing the lower glume partly covering the lower part of the lemma.
4. Back view of spikelet showing the sides of the lower glume partly covering the base of the fruiting lemma.
5. Lower glume.
6. Sterile glume.
7. Fruiting glume.
8. Fruiting glume with its palea.

Fig. 2—*Echinochloa frumentacea.*

1. Inflorescence.
2. Portion of stem and leaf showing the ligule.
3. Front view of spikelet showing the lower glume partly covering the lower part of the lemma.
4. Back view of spikelet showing the sides of the lower glume partly covering the base of the fruiting lemma.
5. Lower glume.
6. Fruiting glune with its palea.

[Magnification : 1+2, $\times\frac{1}{2}$; 3–6, $\times 6$.]

The *leaf sheaths* are glabrous. A ligule is absent but its position is marked by a discoloured semi-lunar obscure ridge. The leaf blades are 2 to 8 in. long by $\frac{1}{8}$ to $\frac{3}{8}$ in. wide, tapering to a fine point. The margins of the leaf are minutely and distantly serrate.

The *inflorescence* is 3 to 5 in. long, inclined, with nodes bearded or not, composed of 8 to 20 racemes which arise at distant points on the main stem which is slender.

The *racemes* are $\frac{1}{2}$ to 1 in. long, slender, usually incurved, not regularly smaller upwards, longer or shorter than the internodes.

The *spikelets* are green or purple, not awned, 1/12 in. long, sessile, arranged in 3 to 5 closely packed rows, more or less hispidly hairy. The lower glume is one-third the length of the upper glume which is of the same length as the sterile lemma, this is paleate and empty. The fruiting lemma is coriaceous and shiny with a coriaceous palea.

(*b*) *Echinochloa frumentacea* (Roxb.) Link (Plate I., fig. 2.).

A tall, robust, annual grass 2 to 4 ft. in height, tufted in habit, with erect stems. The plants are green or purplish. After flowering, the base of the stems becomes decumbent and roots at the nodes.

The *stems* are terete and glabrous.

The *leaf sheaths* are glabrous. A ligule is absent, but its position is marked by a discoloured, semi-lunar obscure ridge.

The *leaf blades* are 6 to 10 in. long, up to $\frac{1}{2}$ in. wide, tapering to a fine point. The margins of the leaf are smooth or minutely and distantly serrate.

The *inflorescence* is 4 to 8 in. long, erect or drooping, with nodes bearded, composed of 8 to 50 racemes which arise close together especially in the upper part of the main stem which is stout.

The *racemes* are $\frac{1}{2}$ to 3 in. long, thickened, often incurved, simple or sometimes branched and corymbosely panicled, gradually shorter upwards, longer than the internodes.

The spikelets are green or purple, not awned, 1/10 to $\frac{1}{8}$ in. long, irregularly crowded, mostly in irregularly-pedicelled fascicles of 3, of which one at least is sessile, hispidly hairy. The lower glume is one-third to half the length of the upper glume which is the same length as the sterile lemma, and this is paleate and male or empty. The fruiting lemma is coriaceous and shiny with a coriaceous palea.

(*c*) *Echinochloa crus-galli* (L.) Beauv. (Plate II., fig 1.)

A tall, robust annual grass 2 to 4 ft. in height, tufted in habit, with erect stems. After flowering, the base of the stems becomes decumbent and roots at the nodes.

The *stems* are terete and glabrous with the nodes glabrous.

The *leafsheaths* are glabrous. A ligule is absent, but its position is marked by a semi-lunar obscure ridge. The leaf blades are 6 to 10 in. long by $\frac{1}{4}$ to $\frac{3}{8}$ in. wide, tapering to a fine point. The margins of the leaf are minutely and distantly serrate.

The *inflorescence* is 4 to 8 in. long, erect with nodes bearded, composed of 8 to 20 racemes which arise on the stout main stem.

The *racemes* are $\frac{1}{2}$ to 2 in. long, simple or sometimes branched, gradually shorter upwards, longer than the internodes.

The *spikelets* are 1/12 to $\frac{1}{8}$ in. long excluding the awn, hispidly hairy with an awn $\frac{1}{4}$ to $\frac{3}{4}$ in. long. The lower glume is one-third to half the length of the upper glume which is the same length as the sterile lemma, this being paleate, male or empty with an awn. The fruiting lemma is coriaceous and shiny with a coriaceous palea.

(*d*) *Echinochloa stagnina* (Retz.) Beauv. (Plate II., fig. 2.)

A tall, robust, perennial grass, 2 to 6 ft. in height, tufted in habit, with erect or usually with long, stout, creeping or floating stems, rooting at the lower nodes especially in the prostrate part of the stem.

The *stems* are terete and glabrous with the nodes glabrous.

The *leaf sheaths* are glabrous or sometimes pubescent near the lower nodes. The Ligule consists of a fringe of stiff hairs. The leaf blades are 6 to 12 in. long by $\frac{1}{4}$ to $\frac{3}{8}$ in. wide, pointed or sometimes tapering to a point. The margins of the leaf are minutely and distantly serrate.

The *inflorescence* is 4 to 8 in. long, erect or drooping with nodes bearded, composed of 7 to 10 racemes which arise on the stout main stem.

The *racemes* are $\frac{1}{2}$ to $1\frac{1}{2}$ in. long, simple or branched, gradually shorter upwards or not, longer than the internodes.

The *spikelets* are $\frac{1}{8}$ to $\frac{1}{6}$ in. long excluding the awn, hispidly hairy, with the awn $\frac{1}{8}$ to $\frac{1}{4}$ in. (sometimes up to $\frac{1}{2}$ in.) long. The lower glume is half the length of the upper glume which is the same length as the sterile lemma and this is paleate, male or empty, with an awn. The fruiting lemma is coriaceous and shiny with a coriaceous palea.

5. Occurrence and Distribution.

(*a*) *E. colona* occurs as a common grass on high land both in the wet and dry zone areas. It has been found as a weed of paddy fields in the following localities, although it does not occur to the same serious extent as the other three species :—

Tissa, Ambalantota, Nildandahinna, Nalanda, Dambulla, Galewela, Paranthan and Pallai.

FIG. 1

E. CRUSGALLI

FIG. 2

E. STAGNINA

Block by Survey Dept. Ceylon

PLATE II.

Fig. 1—*Echinochloa crus-galli.*

1. Inflorescence.
2. Portion of stem and leaf showing the ligule.
3. Front view of spikelet showing the lower glume partly covering the lower part of the lemma.
4. Back view of spikelet showing the sides of the lower glume partly covering the base of the fruiting lemma.
5. Lower glume.
6. Fruiting glume with its palea.

Fig. 2—*Echinochloa stagnina.*

1. Inflorescence.
2. Portion of stem and leaf showing the ligule.
3. Front view of spikelet showing the lower glume partly covering the lower part of the lemma.
4. Back view of spikelet showing the sides of the lower glume partly covering the base of the fruiting lemma.
5. Lower glume.
6. Fruiting glume with its palea.

[Magnification : 1 & 2, $\times \frac{1}{2}$; 3–6, $\times 6$.]

(*b*) *E. frumentacea* was first recorded in 1900 at the Peradeniya Botanical Gardens. It is a cultivated plant known as the Barnyard Millet which has escaped and become naturalized in the low country, especially in paddy fields in the dry zone. It is grown to a small extent in certain parts of India as a grain by the poorer classes and is regarded as a good famine crop. In Egypt, it is known as *Dineba* and is used as a test crop in alkali land which is being reclaimed. In the United States of America, it is grown as a forage grass, known as " Japanese Millet " and at one time was exploited under the name of " Billion-dollar " grass (Hitchcock). It is very palatable to stock.

Next to *E. stagnina*, it is the most troublesome species and occurs in the following localities :—

Tissa, Ambalantota, Lunawa, Parts of Pata and Uda Hewaheta, and Pata and Uda Dumbara, Nalanda, Dambulla, Galewela, Anuradhapura, Vavuniya, Mannar and Paranthan.

It is particularly bad at Nalanda and Paranthan.

(*c*) *E. crus-galli* is the least widespread species. It had a reputation for being a serious weed, but this was in most cases due to the fact that it was confused with *E. stagnina*. It is known in the United States of America as Barnyard Grass and is very palatable to stock.

It has been recorded in paddy fields from the following localities, but it cannot be considered as a serious weed to the same extent as either *E. stagnina* or *E. frumentacea* :—

Tissa, Ambalantota, parts of Pata and Uda Dumbara and Tabbowa.

(*d*) *E. stagnina* is the most serious and the commonest of the four species. It was first recorded by Gardner in 1848 at Peradeniya. It is also relished by stock, but has not been expressly grown as a forage grass.

This weed has been recorded in paddy fields from the following localities :—

Tissa, Ambalantota, Negombo, alongside the Peradeniya–Gampola road and the Katugastota-Galagedera road, Delwita, parts of Pata and Uda Dumbara and Pata and Uda Hewaheta, Nildandahinna, Nikaweratiya, Hettipola, Nalanda, Tabbowa Minneriya, Anuradhapura and Murunkan.

6. Propagation.

All species of *Echinochloa* seed freely and the seeds which are shed in the field from plants whose ear heads are allowed to mature, germinate sooner or later. It is not exactly known how long the seeds remain viable in the soil but in previously infested fields, a large number of seedlings develop soon after preparatory

tillage operations have commenced and during the early stages of growth of the paddy crop. The seedlings grow rapidly and in about six weeks time commence flowering.

Soon after flowering, the basal portions of old stems of all species become decumbent. New shoots arise at these nodes, which root in contact with the soil or with water. These shoots may flower very early, when only a few inches high (Plate III., fig. 2). If the soil remains moist, the internodes soon decay and separate plants are thus developed from the nodes at the basal portions of the parent stems. It is, therefore, necessary that in uprooting any *Echinochloa* plant, no fragments of well-developed stems should be left within a few inches of the surface of the soil, as these are liable to produce new plants so long as each fragment contains one or more nodes.

In standing paddy, it is difficult to distinguish *Echinochloa* plants, before they have flowered unless an examination of individual plants is made. Paddy plants, however, possess a lanceolate, bifid ligule, about 1 in. long (Pl. III., fig. 1) whereas in *Echinochloa*, the ligule is either absent or a fringe of hairs.

Owing to the fact that *Echinochloa* flowers very early, it can be easily recognized before the paddy crop reaches the flowering stage, from the general appearance of its ear heads

As will be seen on reference to Plates I. and II., the four species can be identified from their ear heads as follows :

(1) *E. colona*—open ear head, no awns. Small grains.
(2) *E. frumentacea*—closed ear head, no awns. Large grains.
(3) *E. crus-galli*—closed ear head. Long awns.
(4) *E. stagnina*—open ear head. Short awns.

A strict vigilance should be maintained in every field for the appearance of any of these four species and as soon the ear heads emerge and these weeds are detected, every *Echinochloa* plant should be uprooted even if the paddy crop is ripening. This should be done before the ear heads mature as otherwise the seed is liable to be shed in the field and germinate at any time or become mined with the seed paddy during harvesting Methods for avoiding the danger of introducing *Echinochloa* seed through seed paddy contaminated with the weed seed on harvesting infested fields have been tested and cultural measures devised for keeping every field clean of all *Echinochloa* growth during the interval between harvesting of paddy and sowing or transplanting the next season's crop A note on the results of these experiments is being prepared for publication. Attention is also drawn to the importance of uprooting every *Echinochloa* plant in the standing paddy, before its ear heads are allowed to mature.

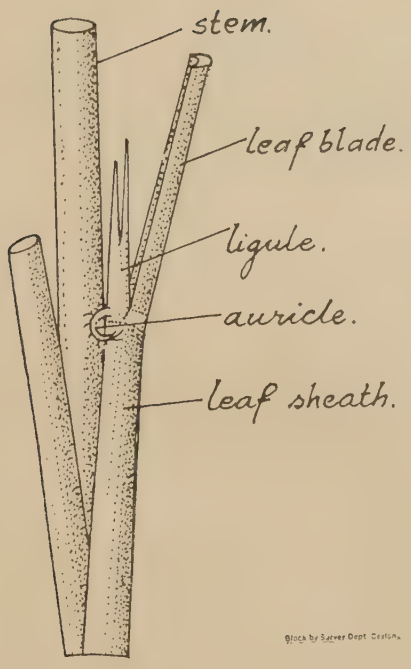

FIG. 1.

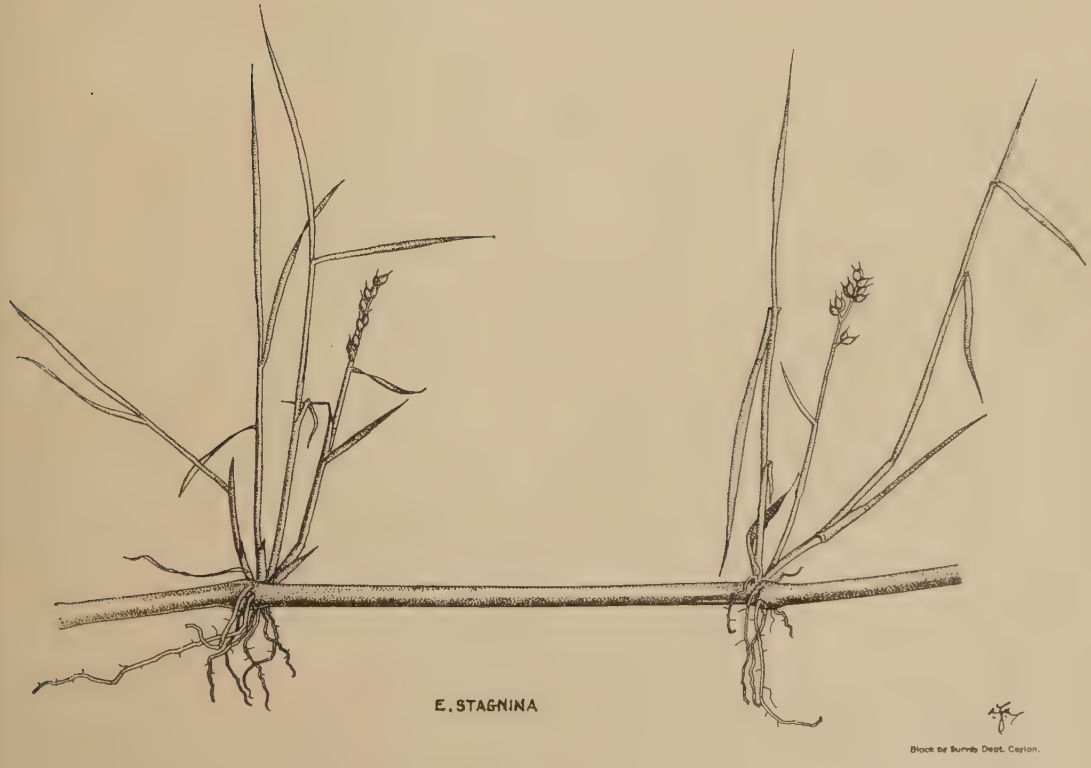

FIG. 2.

PLATE III.

Fig. 1—Part of stem and leaf of the paddy plant showing the ligule (× 1).

Fig. 2—Part of prostrate stem of *E. Stagnina* showing development of shoots and roots at nodes (× ½).

SUMMARY

Four species of *Echinochloa* viz : *E. colona*, *E. frumentacea*, *E. crus-galli* and *E. stagnina* have been found in Ceylon and occur as noxious weeds under the common local names of *maruk* (Sinhalese) and *kuthiraivali* (Tamil). They serve as an alternate host to the paddy fly.

2. A description of each species, its distribution and relative seriousness are given.

3. All species grow rapidly from seed and from stolons produced at the base of the parent stems, soon after these have flowered. Flowering takes place early and at this stage each species can be readily recognized in the standing paddy.

[*Note.*—Since this paper was sent to the press, an article entitled " Studies in the Barnyard Millet—*Echinochloa colona* var. *frumentacea* C.E.C. Fischer, by G. N Rangaswami Ayyangar and U. L. Srinivasa Rao appeared in the January 1940 number of the *Madras Agricultural Journal*. In that article, *E. frumentacea* (Roxb.) Link is considered to be *E. colona* var. *frumentacea* C. E. C. Fischer. The author of this combination is really Ridley (Flora, Malayan Peninsula, Vol. 5, 1925) and the citation should be (Roxb.) Ridley. We, however, consider *E. frumentacea* (Roxb.) Link to be sufficiently distinct from *E. colona* (L.) Link to merit specific rank. The same view is taken by Bews (The World's Grasses) and the Russian systematists (The Flora of the U.S.S.R.]

W.R.C.P.
J.E.S.

SELECTED ARTICLES

LIME IS A CORNER STONE OF INCREASED PRODUCTION*

MORE than 2,000 years ago the Romans knew that lime increased the the productiveness of many soils, and to-day lime is becoming more and more widely used throughout this country. But lime has not always been appreciated; its use has in fact been alternately praised and condemned throughout the development of the arts of farming.

We read of the 17th Century practice of "chalking" the land, when tons of lime were laboriously spread in heavy dressings over quite considerable areas, and along with these descriptions are frequent references to the benefits to the land and crop which followed.

Later came the reaction when the initial increased production brought about by the lime began to fall off through—as we now know—the extra draft made upon the other plant foods of the soil, and the views of the farmers of this period are recalled in the familiar old saying :—

"Lime enriches the father,
Improverishes the son."

But this view is only half a truth, for adequate liming, coupled with the use of fertilizers and good seed, can enrich both the father and the son.

Now that the value of liming is becoming more widely recognized it seems desirable to draw more attention to lime itself. In everyday language the word "lime" may mean any one of a number of substances which are sometimes used for soil improvement, and "liming" means the application of one or more of these materials on the soil. In agriculture, lime usually refers to ground limestone rock.

Origin of Lime

Nearly all natural waters contain lime which has been dissolved out of the rocks or soil through which the water has passed. In this way the rocks and soil gradually lose their lime, which is washed down into drainage basins or out to sea, where it is either deposited through chemical changes or it is taken up by shell fish and minute organisms to be used in building up their protective coverings. When these organisms die their shells fall to the sea floor where, over thousands of years, they accumulate to produce great beds of limestone.

Some of these beds consist almost entirely of the shell cases of minute organisms, and these produce the "chalks" while the larger shell cases produce the "shell" limes. Other beds are cemented together by iron compounds

* By M. M. Burns, Lecturer, Canterbury Agricultural College, in *The New Zealand Journal of Agriculture*, Vol. 61, No. 6, December, 1940.

and or lime itself to produce the hard and soft limestones, whereas beds which have been subjected to great pressure may actually be changed to marble, the hardest and purest form of lime.

Then, again, as lime is deposited under the sea, the commonest impurities are sand and mud ; low-grade limestones containing much clay and sand are often referred to as " papa," and those containing mud as " marls."

Different forms of lime are extensively used in industry, as well as in agriculture. The soft limestones are used to prepare whiting, the hard limestone and marble for building stone and facings, and after burning, for preparation of mortar, while the limestone marls are used as a basis for cement.

How Soils lose Lime

Soils in all regions where the rainfall is greater than the evaporation tend to lose lime and to become sour or acid, or if already sour to become still more so.

Rain water contains some acid which together with that developing as a result in the decay of the organic matter, dissolves lime, magnesia, and similar materials from the rocks and soil through which it percolates. These are lost in the drainage, the amount being greatest under conditions of free drainage and high rainfall.

Although the amounts of lime lost in this way under New Zealand conditions have not been measured, results from similar soils overseas under a 30-inch rainfall show that these losses would be equivalent to about 300 to 500 lb. of limestone per acre per year. On this basis, approximately one ton of limestone per acre or its equivalent in other forms of lime will be needed every four to six years to make good the drainage loss of lime under this rainfall. For districts with higher rainfall, the amounts required would be still greater.

Perhaps the most striking illustration of the loss of lime through leaching by drainage is shown on the limestone country itself, for here it is not unusual for the top soil to have lost so much lime that it is quite acid.

All agricultural crops absorb lime, so that the soil is gradually depleted of this material by the growing of crops and grazing of animals. However, the amount of lime thus carried away is small compared with that lost in the drainage. Some fertilizers, such as nitrate of soda and sulphate of ammonia, tend to increase the loss of lime slightly, while others, such as basic slag and blood and bone, tend to increase the supply.

Soils which need Lime

Soils deficient in lime are frequently called sour or acid. Sour clay soils are usually heavy, slow-draining and sticky when wet, while the lighter stony soils which are sour are readily distinguished by the dominance of hairgrass, sweet vernal, and sorrel in the pastures. Careful observation of the kind and the condition of the vegetation often furnishes valuable information on the lime status of the soil.

Certain plants, such as lucerne, red clover, mangolds, and barley, make strong growth only on soils that are well supplied with lime. White clover, wheat, and ryegrass make good growth on soils which contain insufficient lime for lucerne or red clover. Oats, potatoes, and lupins will grow fairly well on

soils that are very low in lime and unsuitable for the crops already mentioned. Certain weeds, such as spurrey, sorrel, sweet vernal, hawkbit, and flat weeds, are also tolerant of very sour conditions, but their presence in large numbers may also result from an impoverished condition of the soil.

In the classification below the crops which require most lime in the soil for strong growth are placed towards the head of each list. Those below have progressively greater tolerance of acidity, and those near the end of each list make good growth on sour soils. Even so, they may still respond to liming.

Relative Lime Needs of General Crops.

Legumes.	Cereals.	Roots.	Grasses and Weeds.
Lucerne	Barley	Sugar beets	Ryegrass
Red clover	Maize	Swedes	Poas
White clover	Wheat	Mangolds	Fescues
Vetches	Oats	Turnips	Cocksfoot
Peas	Rye	Carrots	Spurrey
Lupins		Potatoes	Sweet vernal

Effect of Lime on the Soil

When lime is added to sour soils it brings about an improvement of the soils and an increase in the yields of crops. These changes may be physical, chemical or biological.

Physical Effects.—Heavy clay soils are made more crumbly, easier to cultivate, less sticky, better drained, and more suitable for plant growth when heavy dressings of lime are applied. Lime is a soil-improver, not a fertilizer. Therefore, the increased growth induced by lime will result in a heavier drain on the other soil materials. This should be balanced by the use of fertilizers.

Chemical Effects.—Apart from adding calcium, which is a plant food, to the soil, liming brings about chemical changes which are commonly called "sweetening." Soil acids are neutralized and harmful conditions associated with these acids are avoided. Lime also increases the efficiency of fertilizers by fixing the phosphate in a soluble form and by promoting the breakdown of the organic matter.

Biological.—The beneficial soil bacteria do more work in soils that contain lime or in those which have a low acidity, either naturally or as a result of liming, than they do in rather sour soils. On the other hand, some undesirable organisms of the soil are favoured by plenty of lime. Such is the fungus which causes potato scab. This potato disease is much less injurious in an acid soil. Excessive lime encourages "root rot" of tobacco, but it reduces markedly the activity of the fungus of the "club root" disease of brassicas.

Forms of Lime in Agriculture

There are two main forms of lime available in this country for use on the soil. These are:—

(1) Carbonates (chemically, calcium carbonate).
(2) Burnt, caustic or quicklime (chemically, calcium oxide).

The carbonate form is found naturally as marble, limestone rock, marl (which is a soft limestone, mixed with silt and clay) and shells. Ground limestone

rock is by far the commonest form of these used in New Zealand, as it is easier to handle and does not burst the bags or spoil when stored or wetted, as does burnt lime.

Colour Unimportant

The effectiveness of ground limestone which varies from nearly white to yellowish gray or deep brown, is unimportant, and cannot be taken as a measure of purity.

The effectiveness of ground limestone in correcting the acidity of soils is dependent upon its carbonate content, the hardness of the stone, and the fineness of grinding. Of these, the percentage of total carbonates present is the most important.

Usually only the highest quality deposits are used for crushing, but the commercial supplies at present made available to farmers cover a very wide range of carbonate contents. This is mainly accounted for by the uneven nature of the deposits, but commercial samples which are consistently low in carbonate content should be supplied at a cheaper rate.

Classification

In general, ground limestones may be classified on the basis of carbonate contents as :—

Over 85 per cent. carbonate : high grade.
70–85 per cent. of carbonate : medium grade.
Below 70 per cent. carbonate : low grade.

There is no simple method of determining purity of ground limestone, but a good idea as to the amount of sand and other inert impurities present can be obtained by treating a small sample in a clean bottle with weak hydrochloric acid or " spirits of salts " which has not been " killed " and noting the amount of undissolved residue.

Generally speaking, a soft rock is more easily ground and is more readily soluble in the soil water than is a hard rock, but the effects of difference in hardness can be very largely overcome by the effects of fineness of grinding. This is very important, for the finer the rock is ground, the more evenly can it be distributed, and the more rapidly will it go into solution. On the other hand, a limestone that is too finely ground will not spread evenly from the topdresser or the drill, and it is more readily lost in the drainage water.

Consequently, ordinary ground limestone should contain a large percentage of fine material which will produce a quick action in the soil, together with sufficient of the coarser fractions which will help it to run through the topdresser and will remain in the soil and continue to give some benefit over a period of years.

Many farmers are fortunate in having outcrops of limestone on their properties suitable for working by portable crushers, while others can use local deposits of soft swamp marl, which may not even require crushing.

Burnt Lime

Burnt lime or quicklime is prepared by burning limestone or shells at red heat, and the purity of the product depends mainly on the carbonate content

of the limestone used. In the process of burning, 100 lb. of pure carbonate loses 44 lb. of gas and yields 56 lb. of burnt lime or calcium oxide. When 100 lb. of a limestone containing only 80 per cent. carbonate (and 20 per cent. impurities) is burned, it will yield only four-fifths as much oxide as the pure stone, or 45 lb.

The impurities are not usually greatly changed by burning, so that the commercial product obtained from 100 lb. of an 80 per cent. carbonate limestone will be made up of 45 lb. of oxide and 20 lb. of impurities, making 65 lb. of an impure quicklime. Of course, the lower the purity of the original rock, the lower will be the quality of the burnt lime produced from it. Even more serious than this variation in the quality of the limestone used for burning is the fact that burnt lime gradually slakes or changes back to its original carbonate form if exposed to moist air, with a consequent fall in the percentage of oxide present.

Generally speaking, the quality of the burnt lime made available to farmers is so uneven and the price so variable that it should not be purchased before making the fullest inquiries as to its purity and its value from officers of the Department of Agriculture.

Both forms of lime have finally much the same effect on soils, but when first applied there is some difference between the effects of burnt lime and of ground limestone. Burnt lime is more soluble and therefore produces its effects on the soil much more quickly than the carbonate, which is only slowly soluble. For this reason it is often used as a preventative for " club root ".

If the unpleasant nature of the burnt lime is not considered, then the choice of which form to apply is largely determined by the costs of cartage and the relative per ton costs of the two forms. One ton of good burnt lime is equal to $1\frac{1}{2}$ to $1\frac{3}{4}$ tons of the ground limestone.

Quantity needed

Although there are many useful laboratory methods of determining the lime requirement of a field, it is essential that the method used should have been checked against field results on a similar soil and that the rainfall, management, kind of crops to be grown, and fertilizers used be taken into consideration before making recommendations on the laboratory results. At best, all recommendations as to the quantity of lime to be applied to a field are approximations.

Local knowledge of a district, its definite soil types, its farming methods, and the responses obtained from fertilizers are invaluable guides to a liming programme, and whenever possible full use should be made of the information available through officers of the Department of Agriculture.

Initial Application

In order to build up the lime status of a sour clay soil to a satisfactory level an initial application of from 1 to $1\frac{1}{2}$ tons per acre may be required, while the equivalent of about 1 ton every four to five years should be applied to maintain the lime status. On the lighter stony soils an initial dressing of from 10 cwt. to 1 ton should be adequate if followed by light annual applications of 2 to 3 cwt. per annum or 1 ton every eight to ten years.

It is of interest to note that in Southland much heavier dressings than these are frequently made and give excellent resu'ts. The common method of applying small dressings of from 1 to 3 cwt. along with superphosphate to pasture is a very satisfactory method of maintaining the lime status of the soil, especially if used after a heavy initial dressing.

An excess of lime in the soil is not desirable, but the quantities which would have to be applied to most lime-deficient soils before detrimental effects upon crops would result are so high that there is little danger of overliming. However as some crops require a higher lime content in the soil than others, it is best to lime for the particular crop to be grown. If a rotation is practised, the application should be made before sowing the particular crop which requires the highest lime content in the soil.

It should be borne in mind that other factors in soil management and manuring are important aids in stimulating growth of clovers and other lime-loving crops on sour soils. Thus, the ploughing-in of green crops or the application of superphosphate, slag, or rock phosphate may so improve soil conditions as to make possible a fair growth of these crops on soils that are otherwise too sour to grow them well.

Application of Lime

Burnt lime or very heavy dressings of the ground limestone should not be applied while any tender crop is growing. These dressings are best made during the final stages in the preparation of a seed bed for a cultivated crop so that the lime becomes thoroughly incorporated with the soil during the process of cultivation. It is not advisable to deep work the lime. If it is harrowed into the top of the seed bed it will be distributed through the lower layers quite rapidly enough in the drainage water. Small annual dressings may be applied to grass land whenever it is convenient, and, except where the lime is applied with fertilizers, the time of application is not important.

During recent years the great expansion in the application of lime during the autumn has resulted in many orders for delivery being delayed. By spreading their demands for lime throughout the year, farmers could reduce congestion at the works.

Effect on Pastures

A large percentage of New Zealand pastures need lime. The use of lime on acid or sour soils tends to encourage the development of perennial ryegrass and clovers. It is desirable to increase the growth of these plants, for they are highly palatable to stock and are high in nutritive value. On permanent pastures to which lime may be applied as a topdressing the soil does not need to be sweetened to a great depth. Accordingly, ½ to 1 ton per acre is usually sufficient for any one application.

If sufficient phosphate is supplied, pasture grasses and clover will grow well on soils that are quite acid. Some soils, moreover, are so strongly acid and so steep or rough that it is uneconomic to lime them under present conditions. Cocksfoot, danthonia, and the fescues make fairly good growth on soils of rather high acidity, and therefore liming on steep areas where these grasses predominate should not be generally adopted.

Lime stimulates Clovers

Generally speaking, lime is of greatest direct benefit to the clovers in the pasture. Clovers are essential for low cost feed production, and the nitrogen which they fix in their roots under favourable soil conditions is required by all non-legume crops (cereals, root crops, and grasses). Indeed, lime is often called an indirect nitrogenous fertilizer for this very reason.

Liming is therefore essential on sour soil for the production of the regular rotation crops, wheat, oats, clover, and ryegrass and turnips. As clover builds up the fertility of the soil, it is the most important of these crops, and lime helps to grow clover. If the clover crop is good, then the crops following it will yield well.

The results of experiments conducted at many centres in New Zealand have shown that liming tends to stimulate the pastures most strongly during summer and autumn, periods that are normally of low production. They have also shown that pastures grown on limed land are richer in both lime and phosphate than are similar pastures grown on unlimed land.

Spread of Effects

The effects of a heavy application of lime may be spread over many years, the length of time depending upon the rainfall and various properties of the soil. For example, an area at Lincoln College which received a dressing of 2 tons per acre is still outstanding after 14 years. Of course, it is impossible to distinguish between the results directly due to the liming and those due to the increased fertility of the soil built up through the stimulation of the clovers in the pasture, but it is important to remember that the interest on an investment in adequate liming is paid year in and year out for a long time, be they years of good growth or drought years. (That limed pastures will resist drought better than unlimed pastures is a point now well known to Canterbury farmers.)

Indeed, the indirect effects of liming upon soil fertility and upon the palatability of pastures are probably of even greater value than is the increased production from the pastures.

Use of Lime with Super

Any form of lime in a ready mixed fertilizer reacts with the soluble phosphoric acid, causing it to revert or change from a readily soluble form to a less soluble form, thereby reducing the availability of the superphosphate used in the mixture. Advantage is taken of this reaction to produce reverted super, the special fertilizer prepared for drilling with seeds which are susceptible to burning when sown in contact with ordinary super. Accordingly, a mixture of lime and super, or reverted super, is usually used when sowing swedes, turnips, and other cruciferous crops. This reversion does not take place to any extent when the lime and super are mixed just before they are applied. (If a mixture of lime and super is to be set aside for some time before use the mixture should be shovelled over a few times at intervals of several hours before it is bagged in order to prevent setting.)

If maximum returns and efficiency from super are desired it is essential that lime be applied to sour soils either before the phosphate is applied or with the phosphate. If phosphate is added directly to sour soils a large amount of the

soluble phosphate is fixed in a form unavailable to crops by iron, aluminium, and other substances which are not active in well-limed soils. Experience has shown that the value of lime is usually increased by the use of fertilizers, and also that fertilizers give the best results when lime is adequate.

SUMMARY

Nearly all natural waters contain lime dissolved out of the rocks and soil. In this way the soil gradually loses its lime and becomes sour or acid ; the lime is transported to the ocean, where it is deposited in beds by the accumulation of dead shellfish and the small marine organisms with shells of lime. Most of the limestone deposits now used in agriculture have accumulated in this way and then have been thrust up from the ocean floor.

Loss of lime, deterioration of pastures, and depletion of fertility go hand in hand and their effects can be offset only by making good these losses of lime. Indeed, adequate liming is a basic step in building up and maintaining the fertility of considerable areas of farming land.

The quantity of lime applied to a soil depends upon the properties of the soil, its management, and the crop to be grown. Soils which are deficient in lime should be given a heavy initial dressing of at least 1 to 1½ tons for heavy soils and ½ to 1 ton for light soils. This should be followed by light annual maintenance dressings or heavy applications spaced at longer intervals.

The most generally suitable form is the ground limestone rock. On cultivated land lime is most effectively applied during the final stages in the preparation of a seed bed for a lime-loving crop. On established pasture lime may be applied at any convenient period of the year. Farmers could help to ensure themselves of prompt deliveries from the works by ordering supplies throughout the year.

Lime tends to encourage clovers which build up the soil fertility ; for this reason lime is often called an indirect nitrogenous fertilizer. Pastures grown on well-limed land are richer in both lime and phosphate.

To obtain the greatest value from fertilizers, the lime content of the soil should be adequate, and conversely the greatest benefit from lime is received when the soil is well fertilized.

SEED INOCULATION OF LEGUMES*

PLANTS of the legume family, such as lucerne, clovers, cowpeas, and soybean have the ability to grow in association with certain bacteria, and, as a result, to make use of the gaseous nitrogen of the air. In this way they differ from most other plants which are able to obtain this essential element only from combined nitrogen in the soil, the supply of which is often low. When this association of bacteria and legume exists, characteristic swellings or nodules are formed on the root system of the host plant, and it is inside these nodules that the nitrogen-assimilating bacteria are found. The bacteria absorb nitrogen from the air, and this is passed on to and utilized by the plant for growth.

Two beneficial results are obtained from this association. Firstly, the legume is furnished with an assured nitrogen supply which assists it to make vigorous growth. In the case of lucerne, clovers, and other pasture legumes, efficient inoculation with the appropriate bacteria greatly aids the rapid establishment of a good stand. Secondly, a method is available for building up the nitrogen content of the soil. When legumes of the green manure type are turned in at the appropriate time there is added to the soil the nitrogen which has been gained from the air and stored temporarily in the plant tissues as nitrogenous compounds. If the correct bacteria are absent, neither of these benefits can be expected and, unfortunately, this would appear to be the case in many agricultural soils in Queensland. Under these conditions seed inoculation with a pure culture of the organism is essential.

A selective action is possessed by most if the nodule bacteria which may accordingly be divided into a number of different types or strains. Each strain is capable of inoculating only a certain legume or group of legumes. The more important agricultural legumes may be separated into seven groups, each requiring a distinct strain of bacteria, which will not associate with legumes of the other groups. These groups are :—(1) Lucerne ; (2) Clovers ; (3) Cowpeas (including peanuts, velvet and lima beans) ; (4) Vetches (including field and garden peas and broad-beans) ; (5) Garden bean ; (6) Soybean ; (7) Lupin.

The bacteria belonging to each of these groups are found to vary amongst themselves in their nitrogen-assimilatory capacity, and while some are very efficient in benefiting the host plant, others may be relatively of little or no value. When providing pure cultures for inoculation purposes an attempt is made to select only those strains which are most efficient.

Three points are therefore evident : Firstly, that it is highly desirable that only inoculated seed be sown on new land. Secondly, that it is incorrect to presuppose the presence of the appropriate strain of bacteria for one legume

* By T. McKnight, B.Sc., Assistant to Research Officer in the *Queensland Agricultural Journal*, Vol. LIV., Part 6, December, 1940.

because another legume well equipped with nodules has been grown before on the same land. Thirdly, that if moderate or even good stands of a particular legume are obtained there is no reason to assume that a further benefit would not accompany inoculation of seed with a selected strain for subsequent sowings.

The Operation of Seed Inoculation

Appropriate bacteria which have been isolated from nodules by bacteriological methods are supplied to the farmer as a culture growing on jelly in a 2-oz. medicine bottle. With each bottle is supplied 3 grams of a bacterial stimulant, calcium phosphate. The inoculum in one bottle is sufficient to treat up to 60 lb. of the larger seed such as cowpeas, or 30 lb. of the smaller seed such as lucerne or clover.

The inoculation process is simple, and consists in wetting the seeds with a suspension of the bacteria in skim milk. The calcium phosphate is dissolved in half a pint of skim milk, and the whole of the bacterial slime in the bottle is then transferred to this mixture. To do this, pour a little of the milk into the bottle and, putting the thumb over the mouth, shake vigorously, and then pour back into the rest of the milk. Repeat this several times until all of the bacterial slime has been washed off.

The seeds should be piled on a clean surface and then inoculated by pouring on the suspension, a little at a time, meanwhile thoroughly mixing the seeds with the hands until every seed is wetted. The seed should then be spread out in a cool, shady place to dry.

It is important to note that inoculated seed should be sown as soon as possible after inoculation, and should be planted only in moist soil. Seed should be drilled in or, if broadcast, harrowed in immediately, as exposure to sunlight kills the bacteria. Inoculated seed should not be sown at the same time as artificial fertilizer, and if possible the most efficient method is to apply the fertilizer in moist soil a day or two before the inoculated seed is planted.

Store the culture in a cool, dark place, and do not remove the cotton wool plug from the mouth of the bottle until the culture is to be used. The culture should be used as soon as possible after receipt, but it may be held for as long as four or five weeks without marked deterioration. If delays hold up sowing longer than this, it is advisable to obtain a fresh culture.

MEETINGS, CONFERENCES, &c.

REPORT OF THE PROCEEDINGS OF THE FIRST MEETING OF THE RE-CONSTITUTED CENTRAL BOARD OF AGRICULTURE HELD AT PERADENIYA IN THE BOARD ROOM OF THE DEPARTMENT OF AGRICULTURE AT 2.30 p.m. ON MONDAY, DECEMBER 9, 1940.

MR. M. CRAWFORD, Acting Director of Agriculture, presided and the following members were present:—Sir James Obeyesekera, Sir Wilfred de Soysa, Messrs. C. Arulambalam, W. H. Attfield, R. H. Bassett (Commissioner for the Development of Agricultural Marketing), C. M. W. Davies, C. N. E. J. de Mel (Principal, School of Agriculture, Peradeniya), L. B. de Mel, R. H. de Mel, Wace de Niese, George E. de Silva, M.S.C., G. de Soyza (Registrar of Co-operative Societies), Bertram de Zylva, A. M. Clement Dias, James P. Fernando (Chairman, Low-Country Products Association of Ceylon), Bruce Gibbon, C. E. Hamilton, J. J. Heider, L. L. Hunter, Dr. A. W. R. Joachim (Chemist), Messrs. K. Kanagasabai, R. C. Kannangara, M.S.C., W. C. Lester-Smith (Chief Advisory Officer, New Rubber Planting Scheme), A. E. Madawela, Mudaliyar S. Muttutamby, Messrs. T. B. Panabokke (Adigar), M. Park (Acting Deputy Director of Agriculture), Dr. S. C. Paul, Dr. W. R. C. Paul (Agricultural Officer, Central Division), Messrs. Wilmot A. Perera, Marcus S. Rockwood, T. M. Saba Ratnam, S. Sivapalan, Rolf Smerdon, R. H. Spencer Schrader, E. R. Tambimuttu, M.S.C., U. B. Unamboowe, Mudaliyar H. E. S. Wickramaratne, Mudaliyar N. Wickramaratne, Mr. A. A. Wickramasinghe, Rev. Father L. W. Wickramasinghe, Col. T. Y. Wright, and Mr. S. C. Fernando, Secretary.

The following members expressed their inability to attend the meeting :—The Conservator of Forests, The Director of Irrigation, the Director of the Coconut Research Scheme of Ceylon, the Director of the Rubber Research Scheme of Ceylon, the Director of the Tea Research Institute of Ceylon, the Commissioner of Lands, Messrs. F. A. E. Price, G. C. Rambukpota, M.S.C., T. B. Poholiadde, and T. B. Ellepola.

The following visitors were also present :—Dr. M. Fernando, Messrs. R. S. S. Goonewardene, T. M. Z. Mahamooth, W. Molegoda, A. V. Richards, and G. V. Wickramasekera.

The Chairman welcomed the new members and in doing so regretted the absence of His Excellency the Governor who had hoped to be present.

Mr. Rolf Smerdon inquired whether a list of the personnel of the Board could be supplied to all members. It was decided to publish a list of members of the Central Board of Agriculture in *The Tropical Agriculturist*.

CONFIRMATION OF MINUTES

The minutes of the last meeting of the previous Board were confirmed, subject to a correction from Mr. Spencer Schrader.

ACTION ON PREVIOUS DECISIONS

The Chairman explained that regulations were already under consideration to control the importation of unsterilized bone manure which had been found to be a source of Anthrax infection.

RULES

The Chairman proposed the adoption of the same Rules as had been adopted by the previous Board.

Mr. Wace de Niese suggested more frequent meetings, perhaps six a year. Mr. Rolf Smerdon pointed out that Rule 1 provided for any number in excess of the minimum three. The Chairman raised the point about additional travelling expenses.

Ultimately it was decided to adopt the following Rule in place of Rule No. 1 :—

" The meetings of the Board shall be held 4 times a year or on any special occasion as may be desired in writing by not less than 15 members of the Board or by the President."

The remaining Rules were adopted without change.

ELECTION OF EXECUTIVE COMMITTEE.

Mudaliyar N. Wickremaratne proposed seven names, but in doing so said he had been asked to do so, which led to a demand by Mr. Wace de Niese– By whom ? A lengthy discussion then ensued. The Chairman stated that he had asked Mudaliyar Wickremaratne to be so good as to propose these names and in doing so he had followed the procedure adopted in the past in order to expedite the business of the meeting. Eventually it was decided to defer the election till the next meeting.

RE-APPOINTMENT OF SUB-COMMITTEE FOR SOIL CONSERVATION ORDINANCE

The Board agreed, on the proposal of the Chairman, to re-appoint the same Sub-Committee as before to consider the draft Soil Conservation Ordinance which was being prepared, its personnel being :—The Land Commissioner, the Director of Public Works, the Director of Medical and Sanitary Services, the Director of Agriculture, the Director of Irrigation, the Conservator of Forests, the Directors of the Tea Research Institute and the Rubber and Coconut Research Schemes, the Agricultural Officer, Soil Conservation, Mr. Rolf Smerdon (representative of the Planters' Association of Ceylon), Mr. S. O. Sirimane (representative of the Low-Country Products Association), three members nominated by the Chairman, Central Board of Agriculture (one of these is the Surveyor-General), the Secretary of the Board to act as Secretary of the Sub-Committee.

Mr. George de Silva suggested a time limit. The Chairman said the new officer would expedite as soon as he was released from his duties under the New Rubber Planting Scheme.

WORK OF THE HORTICULTURAL BRANCH

Mr. A. V. Richards, Assistant Horticultural Officer, then read a paper on the work of his division. (Reproduced in last month's issue of *The Tropical Agriculturist*). The Chairman in introducing him informed the Board that he had returned recently after studying fruit-growing in America. Discussion was invited.

Col. Wright inquired if the Fruit Fly infested Grape Fruit. Mr. Richards detailed the methods advised by the Entomologist. Mr. Bruce Gibbon said that Fruit Fly could be controlled by means of poison bait of jaggery and lead arsenate in a cigarette tin.

Mudaliyar H. E. S. Wickremaratne suggested encouraging private nurserymen, especially youths trained in agricultural farms. The Chairman agreed it was an excellent idea for promoting fruit culture.

Mr. Marcus S. Rockwood said he had tackled both the Fruit Fly and the Fruit Moth. Both were equally bad. Arsenate of lead alone could not prevent great damage. Chilaw, Bingiriya and Up-country saw the worst infestations. He was of the opinion that there was some other host besides citrus and that further investigation was necessary. He feared this menace might one day outrival even the Mediterranean Fruit Fly. Villagers should be educated in precautions such as destroying fallen fruit.

Mr. A. M. C. Dias inquired about manure. Mr. Richards said the Chemist, Dr. Joachim, had prepared a programme based on the age of the plant, which he outlined.

Sir James Obeyesekera inquired as to the possibility of growing olives in Ceylon; wild olives grew in Ceylon and there was a demand for olive oil. Mr. Richards replied that olives grew in sub-tropical climates. Dr. Joachim added that olives require a calcareous soil. Mr. George de Silva inquired whether oil could be extracted from the wild olive. Mr. Richards said it could not and Dr. Joachim explained it was known as the "wild olive" in Ceylon but was not really an olive at all.

Col. Wright inquired whether anything had been done to prevent the yellowing of mangosteen. He had asked the same question of Sir Frank Stockdale 20 years ago. Mr. Richards said this yellowing, viz., gamboge, was due to a physiological disorder which had not yet been satisfactorily explained. Apparently some of it was due to damage in packing, and sunburn. Dr. Joachim remarked that manurial trials were being carried out in Kalutara District as a method of correction. It was hoped to report in a year.

Mr. C. Arulambalam said he once drew attention to electrical treatment in Horticulture and cited the instance of an orange tree in Benares which yielded profusely to such treatment after being barren for 10 years. Mr. Richards replied that such treatment was being tried. Dr. Joachim said the method was simple: the base of the tree was enclosed with wire netting. The Benares experiment cannot be considered to be conclusive without further data; perhaps a favourable season by itself induced the fruiting.

The Chairman thanked all who had joined in the discussion and promised that Mr. Rockwood's remarks on the Fruit Fly would be particularly noted for further action.

OBJECTIVES IN VEGETABLE BREEDING

The summary of replies to the Questionnaire was tabled. There was no discussion.

RESOLUTIONS

Co-ordination of Work.—Mudaliyar N. Wickremaratne moved: "That this Board urges the necessity of the appointment of an agricultural officer, preferably

the Agricultural Officer (Propaganda), to assist in the proper organization and functioning of the Divisional Agricultural Associations co-ordinating the work of the Associations with the District Agricultural Committees and the Central Board of Agriculture."

In doing so he said that the local agricultural associations which were created to ensure due representation of village interests on the Board had a disappointing record. In 1936 the Board had adopted a resolution sponsored by him for an Agricultural Officer to be detailed specially to the work of co-ordinating their activities but no appointment had yet been made. He urged that the Propaganda Officer with his special aptitude and experience should devote even part of his time to this work. It appeared that resolutions from the Divisional Associations were often not even forwarded to the District Committees.

Mr. Wilmot A. Perera, seconding, said the fundamental difficulty was that these Associations were purely advisory and there was also the language difficulty, their proceedings being in the vernacular, whilst the Committees deliberated in English.

Mr. Rolf Smerdon remarked that the resolution revealed a serious indictment on Agricultural Instructors who happened to be the Secretaries. His own experience as a member in both types was that the Divisional Associations spent all their time passing resolutions, and the District Committees in turning them down, with the result that resolutions never come up to the Board.

Mudaliyar H. E. S. Wickremaratne said he often had to send his car round to collect members for meetings. He thought the local Instructor with his local knowledge was still to be preferred. Mr. C. Sivapalan agreed and added that as these Instructors sent copies of minutes to the Divisional Agricultural Officers the latter could at least take notice when attending to their executive functions in the Division.

Mr. E. R. Tambimuttu thought the real reason for their apathy was that they never seemed to be able to get sufficient funds to implement resolutions. Mr. T. B. Pannabokke, Adigar, said in his experience this apathy was due entirely to a sense of futility.

Mr. R. C. Kannangara said he preferred the local instructor and Mr. George de Silva said he would advocate concentrated effort in one place as an experiment. Mr. C. Sivapalan pointed out certain difficulties, *e.g.*, when as in Tamblegam an instructor had to cover a huge range. Recently the Trincomalee District had succeeded in growing large quantities of onions but the credit for this was due to the special food production officer.

The Chairman wound up the discussion by assuring the Board that the Department was always ready to bear in mind resolutions of this sort. It should not be possible for the Agricultural Officer, Propaganda, to devote his full time to the meetings but wherever possible he would arrange field days, &c., to coincide with meetings of the districts.

Subsidy to Paddy.—Mudaliyar N. Wickremaratne next moved the following resolution :—" That this Board urges the early adoption of a direct subsidy to paddy cultivation with a view to bring under regular cultivation all available paddy lands in the Island and thus to (*a*) increase the local production of paddy,

(*b*) give a fair return to the cultivator for the labour and energy spent on the cultivation, (*c*) wean the flow of a large sum of money annually out of this country, and (*d*) meet a fair share of the local requirements by local production."

The Mudaliyar began by asking members to face the reality of present prices. Last year a bag of rice cost Rs. 9·75 to Rs. 12·50 : to-day it was Rs. 12 to Rs. 16. How would this affect the labouring class and those who employed servants ? In 1935 he had carried a resolution urging the fixing of a minimum price for paddy. He found that many Minneriya cultivators had to sell paddy at 90 cents per bushel to boutique-keepers who sold later for Re. 1·25. The Chairman of the Minneriya Development Board once communicated with the Marketing Department and paddy fetched Re. 1·30. But only some 6,000 bushels were affected. He thought a direct subsidy preferable to schemes such as distribution of seed paddy and irrigation improvements. This season the Island had paid Rs. 3½ million more for its rice.

In concluding he pointed out that a subsidy would produce the incidental advantage of accurate statistics. This was so under the Paddy Tax till 1887. The subsidy could be made on a bushel or an acreage basis, 2 bushels sowing extent to count as 1 acre.

Mr. James P. Fernando, who seconded, said he moved a similar resolution before the Low-Country Products Association on March 13th last with the object of eliminating our dependence on foreign supplies of our staple food. He had suggested a subsidy of Rs. 20 per acre to bring new land under cultivation followed by adequate supplies of manure in the 2nd and 3rd years, the value of which could be recovered from the crops. He had advised a vote of Rs. 1 million or in the alternative 10 cents a bushel on imported rice to yield the same figure. He anticipated that about 100,000 acres of new land would be brought under cultivation with such a scheme. The chief difficulty now was poverty and lack of capital. Even Re. 1·25 was an uneconomic price. He suggested Rs. 2 as the minimum, to be imposed for an appreciable period subject to a gradual reduction on a sliding scale. If the present estimated acreage of 850,000 was correct the yield would have to be 75 or 80 bushels per acre to make the Island self-supporting in rice. Therefore the sole remedy was expansion.

Mr. K. Kanagasabai, said he fully supported the idea of State Aid. Assistance might assume three forms—a subsidy, guaranteed price, or a protective tariff. A subsidy was objectionable because it generally benefited the absentee landowner ; it would also embarass Government financially. The guaranteed price could not be successful until the Co-operative movement took a firm hold with marketing agencies to supplement its activities. The protective tariff was the only sensible and reasonable method. It would not embarass Government, its benefits would accrue equally, and its effects would be felt in the remotest parts. A tariff of 50 cents a bushel would yield Rs. 13½ million. This 50 cents would cause a rise of only 2/5 cents per head of population per day in rice prices. At the same time on the estimated acreage of 850,000 it would provide an indirect subsidy of Rs. 16 per acre. In India there was a movement to increase the export duty on rice. Why not impose an import duty ourselves and stimulate our own industry ?

Mr. C. Arulambalam, said we were now in an age of economic nationalism and self-sufficiency and far from the days of the H. M. Fernando school of thought who were all for concentrating on economic crops to the neglect of food crops which they said could be comfortably imported with consequent large profits. But for further self-sufficiency, he added, there must be some permanence in the scale of prices. During the last rice crisis the price of paddy rose to Rs. 6 a bushel and there was a rush to increase the area under paddy. But with the return to normalty much of the new land was abandoned. Perhaps the Quota Ordinance provided the basis for a guaranteed price now.

Colonel Wright asked whether the man who produced 50 bushels per acre was to be subsidized in the same way as the man who secured only 12 or 14.

Mr. George de Silva said the State was subsidizing paddy-growing already, *e.g.*, mills were run at a loss, irrigation rates were waived, &c., though it was not the cultivator that generally benefited. He was for intensive rather than extensive cultivation. He could not see how a tariff could stimulate local production. He suggested that a Select Committee of the Board or the Executive Committee should consider the form a subsidy should take.

Mr. R. C. Kannangara maintained that a subsidy would be of little avail without restriction on cheap imported rice. Our land laws should be changed to eliminate joint-ownership and fragmentation of holdings. Minor helps from Government to-day such as waiver of rates really benefited only $\frac{1}{4}$ of the cultivators who were peasant proprietors, the other $\frac{3}{4}$ interested in paddy being also owners of extensive acreages of economic crops to which they paid almost all their attention.

Mr. Wace de Niese supported a protective tariff though he doubted if any State Councillor would vote for it.

Mr. A. M. C. Dias refuted the belief that paddy did not pay. It depended largely on the will and the till. He had secured a yield of 496 measures from 3 measures of transplanted paddy ; 12 to 15 acres which yielded only 200 bushels had given him 470 under expert care, and he was hoping to get 600. To improve the yield pure line paddy should be used all over Ceylon.

Mr. Wilmot Perera asked whether the waiver of irrigation rates was an accepted policy now. Mr. R. C. Kannangara said steps were being taken to alter irrigation laws, which were a preliminary to giving effect to the State Council resolution.

The Chairman intervening remarked that to his mind a bushel basis of subsidy was not practicable in Ceylon. It was easy with sugar beet in England because all beet went to a small number of factories. Much of the paddy was consumed by the cultivator and sales were often in small parcels to a very large number of purchasers. The acreage basis also teemed with difficulties. The subsidy should be paid only for satisfactory cultivation which would require an army of inspectors to assess. The difficulty about a quota was that we imported rice and not paddy. Before a quota could be introduced we must have many more mills. Probably the paddy industry was already more subsidized than any other.

Mr. L. B. de Mel invited Mr. Bassett's remarks on the problem of the mills. He wondered whether the Marketing Department could absorb all the paddy grown and ready for milling.

Mr. Bassett said members had proceeded on several incorrect assumptions. Two of these were that none of the money benefited the cultivators and that huge stocks of rice had been mysteriously accumulated. From his register he could say that at harvest time money paid did go to the cultivators. The size of the mills was an important factor. The Anuradhapura one was an experimental mill. Even working 3 shifts it could not absorb all the paddy offered it. When the Department stopped buying the producer was obliged to sell to dealers who took the opportunity of resumption of purchases to sell at a higher price. The solution seemed to lie in Co-operative stores and sales for producers, as the Department could not run the risk of wastage.

Mr. Wilmot Perera inquired whether rice sold at the Old Town Hall Market carried the Department's guarantee. Mr. Bassett said it did not but the dealer who was a tenant of the Department was under supervision.

Mr. Bassett added that the lowest price paid by him was Re. 1·40 for paddy delivered at the mill ; the highest Re. 1·80. The oldest stock at present in the mill was only 3 days old. It was hoped soon to have larger mills in operation with a capacity of about 12,000 bushels per month as compared with Anuradhapura's 4,800.

On the Chairman's suggestion, the mover agreeing it was unanimously decided to refer the resolution to the Executive Committee of the Central Board of Agriculture.

BETEL VINE INDUSTRY IN JAFFNA DISTRICT

On Mudaliyar Wickremaratne agreeing to defer his third resolution Mr. Arulambalam moved the following resolution after drawing the attention of members to his memorandum which had been circulated :—" That the Central Board of Agriculture recommends to the Department of Agriculture that an early investigation be made into the prevailing conditions of the betel-vine growing industry in the Jaffna District with a view to find out the causes which have led to its decline, and to suggest and carry out remedies for the improvement of this industry which, next to the tobacco industry, is one of the important income giving agricultural industries in the District."

Mr. R. C. Kannangara seconding said that something should be done to find a disease resisting variety of betel suitable to this country.

Mr. James P. Fernando stated that betel disease was prevalent in the North-Western Province too.

Dr. W. R. C. Paul agreed there had been a definite decline in production and added that the problem had been under investigation since 1937. Indian varieties had recently found their way into the Ceylon market in increasing quantities. Betel growing, he proceeded, was a highly intensive type of market gardening somewhat comparable to the forced tomato plants raised in glass houses in England. The methods of cultivation in use in Jaffna are designed to produce a humid atmosphere and an even temperature. Such conditions favour the development of parasitic organisms and unless steps are taken to check the spread of the two diseases which occur in Ceylon, viz., Bacterial leaf spot and collar rot either by direct methods such as spraying or indirectly by modifying the methods of cultivation and so rendering conditions less favourable for these organisms there will be a serious loss in yields.

Dr. Paul referred to an article written by him in *The Tropical Agriculturist* for November, 1937, wherein he advocated.

1. The reduction of shade by the use of *Sesbania grandiflora* (S. *Katurumurunga* ; T. *Agati*) as standards as in India instead of *Erythrina indica* (T. *mullumuruku*) which casts too heavy a shade.

2. The reduction of excessive moisture in the soil around each vine by the construction of flat or slightly raised beds with channels running between them along the two longer sides. The basin system of irrigation is avoided in this way.

3. The reduction of the frequency of irrigation.

It was noteworthy that neither of the diseases prevalent in Jaffna occurred in Mannar where Jaffna methods were not adopted.

Jaffna betel has become expensive owing to low yields due to disease, higher wages and more intensive methods. Therefore the cheaper betel from the Western and North-Western Province have found their way into Jaffna markets even though they were admitted to be inferior. This is sold at 5 to 10 cents per 100.

Indian betel is being sold in increasing quantities, though originally imported only for special occasions such as temple festivities and weddings. This is too mild for the Jaffna palate but chewing of Indian betel is becoming fashionable. The two varieties commonly imported are Ravasse and Kapurakode and trials are in progress at Jaffna, Horana, and Wagolla.

Colonel Wright inquired whether the experts could not find something else to chew, at least something which will not cause a bloody mouth.

Sir Wilfred de Soysa inquired why the demand could not be satisfied from the South of Ceylon.

The Chairman remarked that a special variety was imported to meet a special taste. Last year imports totalled Rs. 15,000. According to Mr. Arulambalam's figures that amount of betel could be produced from 1 acre so that the imports were not big as far as the area was concerned. Continuing, he assured members that the Department would press forward with the methods advocated by Dr. Paul. Cuttings could be made available to those who wanted them.

The resolution was unanimously adopted.

As it was then 5.30 P.M. the Chairman suggested adjournment.

Mr. Bruce Gibbon inquired if meetings could commence at 10.30 A.M. and continue till 5.30 P.M. with a break for lunch, since it seemed impossible to get through the agenda. Mr. R. C. Kannangara suggested 11 A.M. instead to suit those who come from long distances. It was agreed that the next meeting should commence at 11 A.M.

As the Board rose Mr. J. J. Heider proposed that members agree to donate the travelling expenses drawn by them as a contribution to The Times of Ceylon War Fund.

The Chairman said it might be left to the decision of individual members.

The meeting then terminated.

S. C. FERNANDO,

Peradeniya, January 7, 1941. Secretary, Central Board of Agriculture.

COCONUT RESEARCH SCHEME

BOARD OF MANAGEMENT

MINUTES OF THE FIFTY-THIRD MEETING OF THE ROARD OF MANAGEMENT, COCONUT RESEARCH SCHEME, HELD IN ROOM NO. 202, NEW SECRETARIAT, COLOMBO, ON FRIDAY, DECEMBER 6, 1940, AT 10.30 A.M.

Present.—Mr. M. Crawford, Acting Director of Agriculture (Chairman); Mr. C. H. Collins, C. C. S. (Treasury Representative); Mr. O. B. M. Cheyne; Mr. James P. Fernando; Mr. A. F. R. Goonewardene; Mr. D. D. Karunaratne, J. P.; Mr. H. W. Peiris; Mr. Dudley Senanayake, M. S. C.; Mr. E. R. Tambimuttu, M. S. C.; Mr. G. Panditteseker a, J. P., U. M. Dr. R. Child, Director of Reasearch, acted as Secretary.

MINUTES

The minutes of the previous meeting held on Friday, September 27, 1940, which had been circulated to members were confirmed.

BOARD OF MANAGEMENT

The Chairman reported that Mr. A. F. R. Goonewardene had been nominated by the Low-Country Products Association as one of its representatives on the Board in place of Mr. L. J. M. Peiris, who had completed his three years of office. The Board expressed its thanks to Mr. L. J. M. Peiris for his services and welcomed Mr. Goonewardene to his first meeting.

ESTATES

(*a*) *Visiting Agent's Reports.*—The reports of the Visiting Agent on his visit to Bandirippuwa and Ratmalagara estates on October 5, 1940, had been circulated. In connection with these, the Director of Research reported that on Bandirippuwa it had been subsequently decided to increase the manuring programme somewhat to deal with 2402 palms instead of 2193.

With regard to Ratmalagara, over 600 vacancies of the 976 numbered in the Visiting Agent's report had been supplied to date.

In reply to Mr. James P. Fernando, the Director of Research said that all crop details, including percentage rejections, copra outturns, &c., would be included in his Annual Reports on the estates. Replying to a further question by Mr. Fernando, the Director of Research said that the Visiting Agent's suggestion of including a progress of works statement in the monthly reports had been adopted.

The reports were approved.

(*b*) *Copra Kiln.*—The Chairman reported that a firm of engineers had written to the Scheme regarding a new type of copra drier, quoting special prices for two sizes of kilns. The Director of Research had expressed the opinion that a case could be made out for the erection of such a kiln on Bandirippuwa estate, both as a commercial proposition and from the point of view of experimentation. The older kiln on the estate was in a very bad state of repair and its replacement had already been recommended by the Board.

After a full discussion the Board decided that the erection of a large kiln could hardly be justified on an estate like Bandirippuwa of 150 acres, but that the small kiln should be purchased. It was desired that the engineering firm and the inventor should co-operate with the technical staff of the Scheme to ensure the efficient working of the kiln.

In reply to a question by Mr. Collins, the Director of Research said that it was the intention to retain in use the newer of two Ceylon types of kiln on Bandirippuwa estate, so that copra drying with the ordinary type of kiln could be studied side by side with the patent kiln.

Mr. Goonewardene raised the question of a design of kiln for small owners, and suggested that the engineering firm in question might be willing to co-operate with the Scheme in this matter. It was decided that the Director of Research should consult them accordingly, and that this subject should be discussed at a later meeting of the Board, at which the firm's engineer might be invited to be present.

PUBLICATIONS SUB-COMMITTEE

This Sub-Committee had been appointed by the Board at the previous meeting to report on the issue of publications. The Sub-Committee had met on October 30, 1940, and the minutes of the meeting had been circulated to the Board in the form of a report making recommendations regarding the better circulation of the Scheme's publications.

The Board approved of the report, and decided to put into effect the Sub-Committee's recommendations.

SMALL-HOLDINGS OFFICER

The following resolution had been passed by the Chilaw Planters' Association at its meeting held on November 21, 1940, and forwarded to the Chairman of the Board :—

> "That the Chairman of the Coconut Research Scheme be requested to take steps early to appoint one or more small-holdings officers to help the owners of coconut lands."

The Board felt that adequate discussion could not be given to the subject at the present meeting, and decided to defer it to the following meeting to be discussed early in the Agenda. In the meantime, it was thought, the Chilaw Planters' Association might be asked to assist the Board by supplementing their resolution with suggestions about the directions in which, in their view, a small-holdings officer could do useful work. The Director of Research was instructed to ask for the Association's assistance on these lines, and to circulate papers before the next meeting.

The Director of Research referred to the fact that the present meeting was likely to be the last which Mr. Collins would attend as Treasury Representative ; he wished to place on record his own deep obligation to Mr. Collins for all the assistance he had so courteously given. The members concurred in expressing their appreciation of the invaluable services Mr. Collins had rendered to the Board.

The meeting terminated at 12.15 P.M.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED DECEMBER 31, 1940

Province, &c.	Disease	No. of Cases up to date since Jan. 1, 1940	Fresh Cases	Deaths	Recoveries	Balance ill	No. shot
Western	Foot-and-mouth disease	237	..	8	229	..	..
	Rabies	20	..	2	..	..	18
	Piroplasmosis	2	..	..	2	..	..
	Contagious Mange	2	..	..	..	..	2
Colombo Municipality	Foot-and-mouth disease	410	..	2	406	..	2
	Rabies	54	8	54	..	..	..
	Bovine Tuberculosis	1	1	..	..	..	1
Cattle Quarantine Station	Anthrax	85	5	85	..	..	..
Central	Foot-and-mouth disease	192	..	1	190	..	1
	Anthrax	4	..	4	..	..	..
	Rabies	36	6	..	..	..	36
	Blackquarter	7	..	7	..	..	..
	Contagious Mange	1	..	..	1	..	..
Southern	Rabies	24	1	3	..	..	21
	Pleuro-pneumonia	20	..	20	..	..	..
Northern	Foot-and-mouth disease	171	30	15	156	..	..
	Rabies	5	..	..	..	..	5
Eastern	Foot-and-mouth disease	28	25	1	3	23	1
North-Western	Contagious Mange	19	4	1	14	4	..
	Rabies	8	..	2	..	..	6
	Hæmorrhagic Septicæmia	13	..	13	..	..	..
	Goat pox	28	..	8	20	..	..
North-Central	Hæmorrhagic Septicæmia	35	..	35	..	..	..
Uva	Foot-and-mouth disease	101	..	13	88	..	..
	Goat Pox	70	..	20	50	..	..
	Rabies	10	..	1	..	..	9
	Blackquarter	30	..	25	5	..	..
Sabaragamuwa	Hæmorrhagic Septicæmia	1	..	1	..	..	..
	Rabies	11	..	3	..	..	8
	Piroplasmosis	4	1	1	3	..	..

Department of Agriculture,
Peradeniya, January 21, 1940.

M. CRAWFORD,
Deputy Director (Animal Husbandry)
and Government Veterinary Surgeon.

METEOROLOGICAL REPORT, DECEMBER, 1940

STATION	TEMPERATURE				HUMIDITY		Amount of Cloud	RAINFALL		
	Mean Maximum	Difference from Average	Mean Minimum	Difference from Average	Day	Night (from Minimum)		Amount	No. of Rainy Days	Difference from Average
	°	°	°	°	%	%		Ins.		Ins.
Agalawatta ..	88·4	+0·9	70·9	—0·4	76	95	4·8	5·97	14	—
Anuradhapura ..	83·8	+0·9	72·7	+3·1	83	95	7·3	4·06	21	— 3·55
Badulla ..	78·3	+1·7	66·7	+2·4	79	92	6·3	11·15	25	— 0·25
Batticaloa ..	82·5	+0·7	75·0	+1·6	83	91	6·2	22·48	24	+ 5·33
Colombo ..	86·5	+1·0	73·2	+1·0	74	93	5·0	1·86	9	— 3·78
Diyatalawa ..	72·9	+0·9	59·8	+1·5	83	97	7·2	8·29	21	+ 0·18
Galle ..	83·9	+0·4	74·3	+1·1	78	90	3·6	7·23	10	— 0·94
Hakgala ..	65·3	—1·3	52·0	—0·3	89	94	7·9	11·49	16	— 1·87
Hambantota ..	85·6	+1·1	74·4	+1·7	78	93	5·0	7·28	17	+ 1·69
Jaffna ..	82·2	—0·2	74·3	+1·6	80	88	7·5	13·45	22	+ 4·00
Kandy ..	83·9	+0·9	69·0	+1·8	82	90	6·3	7·38	18	— 1·68
Kurunegala ..	86·1	+0·1	71·9	+1·6	74	95	6·5	6·08	15	— 1·05
Lunuwila ..	87·5	+1·1	73·3	+1·8	77	95	5·2	2·85	13	—
Mannar ..	82·2	—0·9	75·8	+1·1	80	86	7·4	6·12	14	— 1·69
Nuwara Eliya ..	68·9	+1·1	50·4	+2·2	76	93	6·8	5·22	14	— 2·80
Puttalam ..	82·2	—2·6	72·4	+1·5	78	98	6·4	2·12	14	— 4·08
Ratnapura ..	89·1	+1·3	73·8	+2·3	76	93	6·4	9·93	17	+ 0·73
Talawakele ..	74·8	+1·3	57·0	+0·9	74	91	5·9	3·24	16	—
Trincomalee ..	81·5	+0·6	75·5	+0·8	81	88	6·8	21·30	17	+ 8·69

The rainfall for December was in deficit over the greater part of the Island. Roughly speaking, excesses were the rule in the extreme north, north-west and east (except in a comparatively small coastal area between Kalmunai and Panawa), while deficits predominated elsewhere. In the hill country and in the extreme south of the Island, however, excesses and deficits were irregularly distributed.

The outstanding excess for the month was 16·14 inches at Vaganeri. Other excesses over 8 inches were Alutnuwara 9·01 inches, Point Pedro 8·79 inches and Andankulam 8·71 inches. The largest deficits were Hiniduma 10·27 inches, Nalanda 7·57 inches and Deanstone 7·31 inches.

Rainfall totals of over 30 inches for the month were recorded at 4 stations, Hendon 42·36 inches, St. Martin's Upper 37·81 inches, Vaganeri 34·44 inches, and St. Martin's Lower 31·14 inches. The lowest total for the month was 1·16 inches at Wester Seaton.

There were altogether 21 daily falls of 5 inches and over reported, the largest being 8·80 inches at Allai on the 9th. The majority of these falls occurred on the 27th.

The weather during December was predominantly of the north-east monsoon type. Most of the rain fell during the first half of the month. The second half was comparatively dry except for the last few days, particularly the 27th, on which day some heavy monsoon rain was experienced on the eastern slopes of the central hills. An appreciable amount of thunderstorm activity was reported in the course of the month.

Temperatures were again above average. The highest shade temperature recorded was 93·1° at Ratnapura on the 24th, while the lowest temperature was 37·8° at Nuwara Eliya on the 26th. Both humidity and cloud amount were generally in excess. Surface winds were predominantly north-easterly and above normal strength.

D. T. E. DASSANAYAKE,
Superintendent Observatory.